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FEASABILITY STUDY REPORT SITE 57 NSWC INDIAN HEAD MD
5/1/2002
TETRA TECH

FEASIBILITY STUDY REPORT
SITE 57 - FORMER DRUM LOADING AREA

INDIAN HEAD DIVISION
NAVAL SURFACE WARFARE CENTER
INDIAN HEAD, MARYLAND

COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT

Submitted to:
Engineering Field Activity Chesapeake
1314 Harwood Street, SE
Washington Navy Yard, D.C. 20374-5018

Submitted by:
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CONTRACT NUMBER N62467-94-D-0888
CONTRACT TASK ORDER 0805

MAY 2002

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ACRONYMS AND ABBREVIATIONS

µg/kg	micrograms per kilogram
µg/L	micrograms per liter
AASHTO	American Association of State Highway and Transportation Officials
ARAR	Applicable or Relevant and Appropriate Requirements
AS/SVE	air sparging/soil vapor extraction
AVS/SEM	acid volatile sulfides/simultaneously extracted metals
AWQC	Ambient Water Quality Criteria
bgs	below ground surface
BOD	biochemical oxygen demand
B&R	Brown and Root
btoc	below top of casing
CAA	Clean Air Act
CAMU	corrective action management unit
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CLEAN	Comprehensive Long-Term Environmental Action Navy
COC	chemical of concern
COD	chemical oxygen demand
COMAR	Code of Maryland Regulations
COPC	chemical of potential concern
CSF	cancer slope factor
CTE	central tendency exposure
CTO	Contract Task Order
CWA	Clean Water Act
DAF	dilution and attenuation factor
DNAPL	dense non-aqueous-phase liquid
E.O.	Executive Order
EE/CA	engineering evaluation/cost analysis
EFACHES	Engineering Field Activity Chesapeake
EPA	United States Environmental Protection Agency
EPC	exposure point concentration
ERA	ecological risk assessment
FS	feasibility study
FSP	field sampling plan
GAC	granular activated carbon

gpm	gallons per minute
GRA	general response action
HASP	health and safety plan
HI	hazard index
HRC	Hydrogen Release Compound
IAS	initial assessment study
IEUBK	Integrated Exposure Uptake Biokinetic
IHDIV-NSWC	Indian Head Division, Naval Surface Warfare Center
kg	kilogram
K_h	horizontal hydraulic conductivity
LDR	land disposal restriction
LUCIP	Land Use Control Implementation Plan
LUCAP	Land Use Control Action Plan
LTM	Long-Term Monitoring
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
MDE	Maryland Department of the Environment
MDNR	Maryland Department of Natural Resources
mg/kg	milligrams per kilogram
MPE	multi-phase extraction
msl	mean sea level
NAAQS	National Ambient Air Quality Standards
NAD	North American Datum
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NESHAPs	National Emission Standards for Hazardous Air Pollutants
NGVD	North American Geodetic Vertical Datum
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NSPS	New Source Performance Standards
O&M	operation and maintenance
ORC	Oxygen Release Compound
OSHA	Occupational Safety and Health Administration
OSWER	Office of Solid Waste and Emergency Response
PAH	polynuclear aromatic hydrocarbon
PCB	polychlorinated biphenyl
P-CPT	piezoelectric cone penetration test
PPE	personal protective equipment

PRB	permeable reactive barrier
PRG	preliminary remediation goal
RAO	remedial action objective
RCRA	Resource Conservation and Recovery Act
RfD	reference dose
RI	remedial investigation
RME	reasonable maximum exposure
ROD	Record of Decision
SDWA	Safe Drinking Water Act
SMCL	Secondary Maximum Contaminant Level
SSL	soil screening level
SVE	soil vapor extraction
SVOC	semivolatile organic compound
SWMU	solid waste management unit
TAL	Target Analyte List
TBC	to be considered
TCE	trichloroethene
TCL	Target Compound List
TOC	total organic carbon
TSD	treatment, storage, and disposal
TtNUS	Tetra Tech NUS, Inc.
TU	temporary unit
USC	United States Code
USCS	Unified Soil Classification System
USDA	United States Department of Agriculture
VOC	volatile organic compound
VPDES	Virginia Pollutant Discharge Elimination System

EXECUTIVE SUMMARY

This Feasibility Study (FS) Report for the Indian Head Division, Naval Surface Warfare Center (IHDIV-NSWC), Indian Head, Maryland, was prepared by Tetra Tech NUS, Inc. in response to Contract Task Order (CTO) 0805, under the Comprehensive Long-Term Environmental Action Navy (CLEAN), Contract Number N62467-94-D-0888. The purpose of this FS Report is to develop and evaluate potential remedial alternatives to mitigate environmental contamination at Site 57 (Former Drum Loading Area). Environmental studies of this site commenced in 1994. A Remedial Investigation (RI) Report prepared in July 2000 (TtNUS, 2000) presented the environmental data collected from the site and evaluated the data to determine the human health and environmental risks resulting from on-site contamination. Additional investigations conducted in August 2001 to fill data gaps and collect data needed to evaluate potential remedial alternatives are discussed in this FS Report.

This FS develops remedial alternatives that address the risks identified in the RI Report. Separate alternatives were developed for soil and groundwater. There are no unacceptable risks to human health and the environment associated with surface water and sediment. Risks to human health are associated with exposure to arsenic in soil under hypothetical future residential and future construction worker exposure scenarios. Risks to human health are also associated with exposure to chlorinated volatile organic compounds (VOCs), primarily trichloroethene (TCE), and diethyl ether in groundwater under a hypthetical future residential exposure scenario. Chlorinated VOCs in soil are the potential ongoing source of groundwater contamination.

Soil Alternative 1 is the no-action alternative, which is included to serve as a baseline against which other soil alternatives can be compared.

Soil Alternative 2 provides for the installation of an impermeable barrier over the source of groundwater contamination. Land use controls would be imposed to prevent human exposure to arsenic in soil.

Soil Alternative 3 provides for the complete removal of all contaminated soil that poses unacceptable risks to human health (under residential and construction worker exposure scenarios) and the environment. The excavated soil would be hauled to a permitted off-site landfill for disposal. No land use controls would be required.

Table ES-1 summarizes the evaluation of soil alternatives and presents the costs for each alternative considered. The soil alternatives were developed and evaluated in accordance with the nine criteria required by the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).

Groundwater Alternative 1 is the no-action alternative, which is included to serve as a baseline against which other groundwater alternatives can be compared.

Groundwater Alternative 2 would allow the contaminants to naturally attenuate. Monitoring would be conducted to evaluate the effectiveness of natural attenuation. Groundwater use restrictions would be imposed to prevent the use of shallow groundwater as a source of drinking water until clean-up goals were attained.

Groundwater Alternative 3 provides for the injection of chemicals into the shallow groundwater to promote in situ biological treatment (biodegradation). Monitoring would be conducted to evaluate the effectiveness of treatment. Short-term groundwater use restrictions would be imposed to prevent the use of shallow groundwater as a source of drinking water until clean-up goals were attained.

Groundwater Alternative 4 provides for the installation of a permeable reactive barrier (PRB) that would remove contaminants as the groundwater flows through the barrier. Monitoring would be conducted to evaluate the effectiveness of the PRB. Groundwater use restrictions would be imposed to prevent the use of shallow groundwater as a source of drinking water until clean-up goals were attained.

Groundwater Alternative 5 provides for the installation of extraction wells to remove contaminated groundwater. The groundwater would be treated using air stripping to remove contaminants. The treated groundwater would be discharged to Mattawoman Creek. Monitoring would be conducted to evaluate the effectiveness of extraction and treatment. Groundwater use restrictions would be imposed to prevent the use of shallow groundwater as a source of drinking water until clean-up goals were attained.

Table ES-2 summarizes the evaluation of groundwater alternatives and presents the costs for each alternative considered. The groundwater alternatives were developed and evaluated in accordance with the nine criteria required by CERCLA.

TABLE ES-1

**SUMMARY OF EVALUATION OF SOIL ALTERNATIVES
SITE 57 – FORMER DRUM LOADING AREA
IHDIV-NSWC, INDIAN HEAD, MARYLAND**

Evaluation Criteria	Alternative 1 – No Action	Alternative 2 – Capping with Land Use Controls	Alternative 3 – Excavation and Off-Site Disposal
Threshold Criteria			
Overall Protection of Human Health and the Environment	No reduction in potential risks.	Cap and land use controls would reduce risks to human health and the environment.	Removal of all contaminated soil would eliminate risks to human health and the environment.
Compliance with ARARs Chemical-specific Location-specific Action-specific	 Would not comply. Not applicable. Not applicable.	 Would comply. No ARARs. Can be designed to attain ARARs that apply. Would comply with state landfill closure requirements.	 Would comply. No ARARs. Would comply. these are applicable ?
Primary Balancing Criteria			
Long-Term Effectiveness and Permanence	Allows risk to remain uncontrolled.	Cap and land use controls would reduce risks. Monitoring and use restrictions provide adequate and reliable controls.	Removal of all contaminated soil would eliminate risks.
Reduction of Toxicity, Mobility, or Volume through Treatment	No treatment.	No treatment.	No treatment.
Short-Term Effectiveness what is actually meant by this?	No short-term impacts or concerns. "none" might be a better word 2nd table uses "not appliable"	Short-term impacts to community associated with off-site transport of contaminated soil. Exposure of workers to contaminated soil can be adequately controlled. No short-term impacts to environment. Would meet RAOs within 3 months.	Short-term impacts to community associated with off-site transport of contaminated soil. Exposure of workers to contaminated soil can be adequately controlled. No short-term impacts to environment. Would meet RAOs within 3 months.

SUMMARY OF EVALUATION OF SOIL ALTERNATIVES
SITE 57 – FORMER DRUM LOADING AREA
IHDIV-NSWC, INDIAN HEAD, MARYLAND

Evaluation Criteria	Alternative 1 – No Action	Alternative 2 – Capping with Land Use Controls	Alternative 3 – Excavation and Off-Site Disposal
Implementability	Nothing to implement. No monitoring to show effectiveness.	Alternative consists of common remediation practices that are available and implementable.	Alternative consists of common remediation practices that are available and implementable.
Costs			
Capital	$0	$492,400	$907,000
O&M	$0	$600 LUCs?	$0
Present Worth	$0	$526,000	$907,000
Modifying Criteria			
State Acceptance	To be determined.	To be determined.	To be determined.
Community Acceptance	To be determined.	To be determined.	To be determined.

$25K · 6 = $150K
although cost would
be combined w/ gw

TABLE ES-2

SUMMARY OF EVALUATION OF GROUNDWATER ALTERNATIVES
SITE 57 – FORMER DRUM DISPOSAL AREA
IHDIV-NSWC, INDIAN HEAD, MARYLAND

Evaluation Criteria	Alternative 1 – No Action	Alternative 2 – Monitored Natural Attenuation	Alternative 3 – In Situ Bioremediation
Threshold Criteria			
Overall Protection of Human Health and the Environment	No reduction in potential risks.	Groundwater use restrictions and monitoring would reduce risks to human health and the environment.	Groundwater treatment and groundwater use restrictions would reduce risks to human health and the environment.
Compliance with ARARs			
Chemical-specific	Would not comply.	Would eventually comply.	Would comply.
Location-specific	Not applicable.	No ARARs.	No ARARs.
Action-specific	Not applicable.	Not applicable.	Can be designed to attain ARARs that apply.
Primary Balancing Criteria			
Long-Term Effectiveness and Permanence	Allows uncontrolled risks to remain.	Groundwater use restrictions would reduce risks to human health. Monitoring and use restrictions provide adequate and reliable controls.	Treatment would be expected to be effective over the long term. Treatability studies needed to confirm effectiveness. — what has been done?
Reduction of Toxicity, Mobility, or Volume through Treatment	No treatment.	No treatment.	In situ biological treatment would reduce toxicity of hazardous substances in groundwater. is "treatment" bio or chem?
Short-Term Effectiveness	Not applicable.	No impacts to community, workers, or environment. One month to implement. Approximately 70 years to attain clean-up goals.	No impacts to community, workers, or environment. Short-term impacts on traffic during chemical injection. Three months to construct. Approximately 1 year to attain clean-up goals, unless additional applications needed. based on?

TABLE ES-2

SUMMARY OF EVALUATION OF GROUNDWATER ALTERNATIVES
SITE 57 – FORMER DRUM DISPOSAL AREA
IHDIV-NSWC, INDIAN HEAD, MARYLAND

Evaluation Criteria	Alternative 1 – No Action	Alternative 2 – Monitored Natural Attenuation	Alternative 3 – In Situ Bioremediation
Implementability	Not applicable.	Groundwater use restrictions can be strictly enforced because site is located at a military facility.	Alternative consists of common remediation practices that are readily available and implementable. Care would need to be taken to avoid damage to underground utilities.
Cost			
Capital	$0	$8,100	$1,229,100 why so high compared to PRB & P&T?
O&M	$0	$29,600	$50,000
Present worth	$0	$397,000	$1,320,000
Modifying Criteria			
State Acceptance	To be determined.	To be determined.	To be determined.
Community Acceptance	To be determined.	To be determined.	To be determined.

TABLE ES-2

SUMMARY OF EVALUATION OF GROUNDWATER ALTERNATIVES
SITE 57 – FORMER DRUM DISPOSAL AREA
IHDIV-NSWC, INDIAN HEAD, MARYLAND

Evaluation Criteria	Alternative 4 – Permeable Reactive Barrier	Alternative 5 – Extraction and Treatment
Threshold Criteria		
Overall Protection of Human Health and the Environment	Groundwater treatment, groundwater use restrictions, and monitoring would reduce risks to human health and the environment.	Groundwater extraction and treatment, groundwater use restrictions, and monitoring would reduce risks to human health and the environment.
Compliance with ARARs		
Chemical-specific	Would comply.	Would comply.
Location-specific	No ARARs.	No ARARs.
Action-specific	Can be designed to attain ARARs that apply.	Can be designed to attain ARARs that apply.
Primary Balancing Criteria		
Long-Term Effectiveness and Permanence	Treatment would be expected to be effective over the long term. Treatability studies needed to confirm effectiveness. Monitoring and use restrictions provide adequate and reliable controls.	Extraction and treatment would be effective over the long term. Monitoring and use restrictions provide adequate and reliable controls.
Reduction of Toxicity, Mobility, or Volume through Treatment	Treatment using PRB would reduce toxicity of hazardous substances in groundwater.	Treatment using air stripping would reduce toxicity of hazardous substances prior to discharge to surface water.
Short-Term Effectiveness	No impacts to community, workers, or environment. Short-term impacts to traffic during PRB construction. Three months to construct. Need additional studies to evaluate time to achieve clean-up goals.	No impacts to community, workers, or environment. Short-term impacts to traffic during installation of wells and piping. Five months to construct. Approximately 19 years to attain clean-up goals.

TABLE ES-2

SUMMARY OF EVALUATION OF GROUNDWATER ALTERNATIVES
SITE 57 – FORMER DRUM DISPOSAL AREA
IHDIV-NSWC, INDIAN HEAD, MARYLAND

Evaluation Criteria	Alternative 4 – Permeable Reactive Barrier	Alternative 5 – Extraction and Treatment
Implementability	Alternative consists of common remediation practices that are readily available and implementable. Care would need to be taken to avoid damage to underground utilities.	Alternative consists of common remediation practices that are readily available and implementable. Care would need to be taken to avoid damage to underground utilities.
Cost		
Capital	$668,200	$410,700
O&M	$20,600	$63,500
Present worth	$1,046,000	$1,083,000
Modifying Criteria		
State Acceptance	To be determined.	To be determined.
Community Acceptance	To be determined.	To be determined.

1.0 INTRODUCTION

1.1 PURPOSE AND ORGANIZATION OF REPORT

This feasibility study (FS) has been prepared for the Engineering Field Activity Chesapeake (EFACHES) by Tetra Tech NUS, Inc. (TtNUS) in response to Contract Task Order (CTO) 0805, under the Comprehensive Long-Term Environmental Action Navy (CLEAN) Contract Number N62467-94-D-0888. The purpose of this FS is to develop and evaluate potential remedial alternatives to mitigate environmental contamination at Site 57, Former Drum Loading Area, at the Indian Head Division, Naval Surface Warfare Center (IHDIV-NSWC), Indian Head, Maryland. The FS summarizes information presented in the Remedial Investigation (RI) Report (TtNUS, 2000), presents and evaluates information that was collected after the RI Report was completed, and discusses the basis for any remedial action that may be required at Site 57. In this report, remedial technologies and process options are evaluated and screened to select those that are most viable for the site conditions and contaminants. The technologies and process options that passed the screening are combined to form remedial alternatives to address site contamination. The remedial alternatives are also evaluated to distinguish positive and negative aspects of each alternative.

Section 1.0 summarizes background information, physical characteristics of the site, the nature and extent of contamination, the results of the human health and ecological risk assessments, and information collected after the RI Report was completed. Section 2.0 presents the objectives and goals of remediation, including preliminary remediation goals, contaminants of concern, and media of concern. Section 3.0 presents the identification and screening of technologies and process options. Section 4.0 presents the development and screening of alternatives. Section 5.0 presents the detailed analysis of alternatives. Section 6.0 presents the comparative analysis of alternatives.

1.2 FACILITY BACKGROUND

1.2.1 Location

The IHIDV-NSWC is located in northwestern Charles County, Maryland, approximately 25 miles southwest of Washington, D.C. The IHDIV-NSWC is a military facility consisting of the main area on the Cornwallis Neck Peninsula and the Annex on Stump Neck. The main area is bounded by the Potomac River to the northwest, west, and south, Mattawoman Creek to the south and east, and the town of Indian Head to the northeast (Figure 1-1). Stump Neck Annex is located across Mattawoman Creek. The Stump Neck Annex is not contiguous with the main area and is operated by a tenant.

1.2.2 Mission

The primary mission of IHDIV-NSWC is as follows:

- Provide services in energetics for all warfare centers through engineering, fleet, and operational support, manufacturing technology, limited production, and industrial base support.

- Provide research, development, testing, and evaluation of energetic materials, ordnance devices, and components and other related ordnance engineering standards including chemicals, propellants, and their propulsion systems, explosives, pyrotechnics, warheads, and simulators.

- Provide support to all warfare centers, military departments, and the ordnance industry for special weapons, explosive safety, and ordnance environmental issues.

- Execute other responsibilities assigned by the Commander of the Activity.

1.2.3 Meteorology

Indian Head experiences a modified, moist, humid, continental climate with warm and wet summers and cool winters. The Appalachian and Blue Ridge Mountain ranges to the west obstruct cold, continental air in the winter, and the Potomac River and Atlantic Ocean contribute to temperatures that are more moderate and to higher humidity. The mean temperature at Indian Head is 58°F [National Oceanic and Atmospheric Administration (NOAA), 1987]. July is typically the warmest month, with an average temperature of 79°F. January is the coldest month, with an average temperature of 35°F. The area receives an average of approximately 39 inches of precipitation per year with approximately 17 inches of snow. Precipitation is uniformly distributed throughout the year (NOAA, 1987).

1.2.4 Physiography and Topography

The Indian Head peninsula is located in the Atlantic Coastal Plain Physiographic Province, approximately 8 to 10 miles east of the Fall Line that marks the western extent of the physiographic province. Indian Head has gently rolling to undulating topography with elevations ranging from sea level to more than 100 feet above mean sea level (msl) (Figure 1-2). The higher elevations are on the eastern portion of the Activity. The land surface generally slopes to the southwest and southeast. The portion of the Activity along the Potomac River is characterized by 20- to 100-foot bluffs. The portion along Mattawoman Creek is more gently sloping.

1.2.5 Soils

The following is a brief description of the soil types in the Indian Head area, as classified by the United States Department of Agriculture (USDA) Soil Survey of Charles County, Maryland (USDA, 1974). The dominant soil series in this area are the Evesboro-Keyport-Elkton Association and the Beltsville-Gravelly Land-Bourne Association. The Evesboro-Keyport-Elkton Association consists of level to moderately sloping, excessively drained, sandy soils and moderately well-drained and poorly drained, level to gently sloping, loamy soils that have clayey subsoil. The Beltsville-Gravelly Land-Bourne Association consists of level or moderately sloping and moderately drained, deep, and dense loamy soils. Areas of cut-and-fill soils are also found on the Activity. Cut-and-fill lands are areas where the native soils have been removed and graded or filled with other material or soil.

1.2.6 Geology

The geologic units underlying the Indian Head peninsula, in ascending stratigraphic order, are the Lower Cretaceous Potomac Group, the Tertiary age Aquia Formation and Park Hall Formation, and several Quaternary fluvial and estuarine deposits (McCartan, 1989). Additional details on the geologic units are provided in Section 3.0 of the RI Report (TtNUS, 2000).

1.2.7 Hydrogeology

The Patapsco and Patuxent Formations of the Potomac Group are the main groundwater aquifers used for water supply purposes in the Indian Head area. Typical screen interval depths for supply wells vary from 150 to 500 feet below ground surface (bgs). The aquifers are separated by the Arundel Formation confining unit. Figure 1-3 presents a generalized cross-sectional view of the Indian Head area.

The three principal water-bearing zones within the Patapsco Formation are the Lower, Middle, and Upper Sands. They are under confined conditions. The Lower Sand crops out in Virginia, the Middle Sand crops out below the Potomac River and in Virginia, and the Upper Sand crops out beneath the Potomac River.

The water-bearing zones of the Patuxent Formation consist of laterally discontinuous sand lenses. The Patuxent Formation crops out in Virginia, where it is recharged by surface water.

Shallow, unconfined to semi-confined groundwater at the Indian Head peninsula occurs from near the ground surface to approximately 45 feet bgs, with water-table elevations ranging from sea level to approximately 65 feet above msl. Typically, shallow groundwater occurs in perched water-bearing zones and is recharged from infiltration. In some lowland areas, surface water intrusion may be an additional source of recharge of the shallow aquifer along the edge of water bodies and during periods of high tide. It is assumed that shallow groundwater flow follows topography and discharges into local water bodies.

The Lower and Middle sands of the Patapsco Formation and the Patuxent Formation of the Potomac Group are the principal aquifers for domestic use at the IHDIV-NSWC. The Upper Sands of the Patapsco Formation are poor producers of groundwater in the area and are not considered an important aquifer. The Upper Sands are considered a confining layer above the underlying Middle and Lower Sand Aquifers in the area and below the shallow, small-scale, surficial water-bearing zones. The Middle Sand aquifer is believed to be hydraulically connected to the Potomac River, where the river has eroded into the aquifer. Potomac River water may be partially recharging the aquifer in this area because of the heavy pumping of supply wells at Indian Head (Hiortdahl, 1990).

1.2.8 Surface Water

The two principal waterways near the Indian Head peninsula are the Potomac River and Mattawoman Creek. The Potomac River is a tidally influenced estuary and is slightly brackish. Mattawoman Creek is a tributary to the Potomac River and is tidally influenced. Tidal marshes exist along Mattawoman Creek.

Wastewater from IHDIV-NSWC is discharged directly to the Potomac River or Mattawoman Creek and from outfalls to tributaries of the Potomac River or Mattawoman Creek. The wastewater consists of industrial, sanitary, and storm effluents or combinations thereof (Hart, 1983).

1.2.9 Population and Land Use

The population of IHDIV-NSWC is approximately 3,300 (ENSAFE/Allen & Hoshall, 1994). This includes 2,000 employees, 1,000 contracted employees, 100 Strauss Avenue residents, and 200 Bachelor Enlisted Quarters residents. Based on the 2000 United States Census, the population of the town of Indian Head is 3,422, and the total population of Charles County is 120,546. The town of Indian Head is primarily residential, with a business corridor located along Maryland Route 210. Tourism comprises a significant portion of the local commerce, because Indian Head is located near some of the best fishing locations on Mattawoman Creek.

1.2.10 Ecology

The information in this section was extracted from the Initial Assessment Study (IAS) Report (Hart, 1983), except where noted.

1.2.10.1 Flora

Approximately 35 percent of IHDIV-NSWC is wooded. The forests consist of hardwoods, including oak and hickory, and of loblolly and Virginia pines. The upland areas are characterized by older growth of pine and oaks, and the lower elevations are composed of sycamore, ash, elm, and sweet gum.

Approximately 53 percent of IHDIV-NSWC is open field and shrub vegetation. Loblolly pine, sweet gum, red cedar, and black locust are typical of these communities.

Along the shoreline and beaches of the Potomac River, black persimmon, false indigo, poison ivy, sea myrtle, grape, and Virginia creeper are present, along with phlox, gama grass, panic grass, Bermuda grass, or finger grass. Marsh areas predominate along the shores of Mattawoman Creek. They are characterized by jewelweed, alger, marsh cattail, weedgrass, sedge, three square bulrush, wild rice, saltmarsh cordgrass, smartweed, and marsh mallow.

1.2.10.2 Wildlife

The ecosystem at IHDIV-NSWC supports a variety of animal life. White-tailed deer are abundant. Other common mammals include opossum, bats, squirrels, mice, raccoon, woodchuck, rabbits, and other burrowing rodents, such as voles and shrews. The birds found within Charles County include grebes, herons, ducks, geese, hawks, kestrels, osprey, eagles, gulls, owls, and perching birds, such as robins, warblers, and jays. Common reptiles and amphibians of Charles County include lizards, skunks, snakes, turtles, salamanders, frogs, and toads.

1.2.10.3 Aquatic Life

The area of the Potomac River adjacent to the Activity is part of the spawning and nursery area for striped bass, white perch, herrings, and shad. Bay anchovies and three species of silversides also spawn and nurse within this area. The area is the upstream limit of the nursery area for estuarine-dependent species, including the Atlantic menhaden and Atlantic croaker. Mattawoman Creek is a spawning area for blueback herring, white and yellow perch, and gizzard shad.

1.2.10.4 Threatened and Endangered Species

A rare, threatened, and endangered species and natural area survey was performed at IHDIV-NSWC by the Maryland Natural Heritage Program [Maryland Department of Natural Resources (MDNR), 1992]. There are no known rare, threatened, sensitive species, or sensitive habitats at Site 57.

1.3 SITE 57 BACKGROUND

1.3.1 Site Location and Description

Site 57, Former Drum Loading Area, encompasses the area located south of Building 292 at the main area of the IHDIV-NSWC (Figure 1-2). Previous operations from the mid-1960s until 1989 involved the use of trichloroethene (TCE) for vapor degreasing and general cleaning. During the 1970s and 1980s, spent TCE was transferred from a tank inside Building 292 into drums via a pipe that passed through the wall near the southern corner of the building. The spent TCE was determined to be U.S. Environmental Protection Agency (EPA) hazardous waste number F002. The drums were reportedly stored on a grass-covered area near manhole MH-1 (Figure 1-4). It is believed that these operations have resulted in the contamination of soil and groundwater. The use of TCE at Building 292 stopped in 1989. Site 57 also includes Buildings 165 and 496, located approximately 150 feet southwest of Building 292, which were used to store ethyl ether.

1.3.2 Topography and Surface Features

The topography and surface features of the site area are shown on Figure 1-4. Building 292 is located in a valley approximately 1,300 feet north of Mattawoman Creek at an elevation of approximately 35 feet above msl. The valley trends approximately southeast toward Mattawoman Creek to approximately 0 feet msl. The valley slopes are much steeper east, north, and west of the site. A storm drain from Building 292 approximately follows the valley and discharges to Mattawoman Creek. An intermittent stream also flows through the valley before discharging to Mattawoman Creek. Portions of an abandoned railroad track are located in the valley.

1.3.3 Site Geology

Generally, the subsurface materials within the stream valley consist of fill material and alluvium. The fill material consists primarily of reworked natural material of gravel, sand, silt, and clay. At some locations, the fill material contains minor amounts of asphalt, concrete, brick, terra cotta, and slag fragments. In areas of construction, the natural soil and alluvium are cut by, or supplemented with, the fill material. Figure 1-5 shows the locations of the generalized geologic cross-sections. Cross-section A-A′ is presented on Figure 1-6. Cross-sections B-B′ and C-C′ are shown on Figure 1-7, and cross-sections D-D′ and E-E′ are illustrated on Figure 1-8.

The alluvium is interpreted as being derived from erosion of the adjacent upland areas. It generally consists of a yellow-brown and gray, poorly sorted sand with minor amounts of gravel, silt, and clay overlying an olive-brown clay, with well-sorted, very fine-grained sand and silt. The elevation of the contact between these two units ranges from approximately 10 feet below to 10 feet above msl. A lens of greenish-gray, very fine-grained, well-sorted sand and silt with a trace of clay is found within the yellow-brown and gray sand unit beneath the southern portion of Building 292. Its upper surface is at approximately 10 feet above msl; however, the thickness of this lens is unknown. Soil borings completed during the RI did not completely penetrate this lens.

The subsurface materials encountered at the adjacent up-land areas are believed to be Middle to Lower Pleistocene age Chicamuxen Church Formation, consisting primarily of yellow brown sand and gravel, clay, and clayey sand.

Five generalized geologic cross-sections (A-A′ to E-E′) were developed to better characterize the subsurface materials underlying Site 57 and areas downgradient from the site. The cross-sections were generated using soil boring logs and cone penetrometer test results. The cone penetrometer test uses direct-push techniques to infer soil types by measuring the stress applied to the point and side of the probe as the probe is being pushed into the ground by a very heavy truck. No visual description of the soil is prepared.

Cross-Section A-A′

Cross-section A-A′ (Figure 1-6) is a northwest to southeast transect looking northeastward that depicts the subsurface materials along the northern portion of the study area, including Site 57, Former Drum Loading Area and Building 292. Fill material is encountered throughout the extent of this section. The fill is identified by traces of brick, terra cotta, and slag fragments in a gravel, sand, and clay matrix. At S57MW013, the bottom of the fill material is defined by a layer of asphalt at 7 feet bgs. At well clusters S57MW001/002, S57MW007/008 and S57MW009/010, fill material is encountered at the ground surface to approximately 7, 8, and 12 feet bgs, respectively. The recovery rate at these locations during split-spoon sampling was very poor and the encountered material was very loose. At S57MW003/004 and S57MW011, the fill material is 8 and 11 feet thick, respectively.

The yellow brown and gray sand unit is encountered below the fill material throughout the cross-section. At location S57MW012/013, the sand unit is approximately 36 feet thick, and it thins to approximately 8 feet in the south at S57MW009/010. At boring locations S57MW001 and S57MW003, a lens of moderately sorted, greenish-gray very fine-grained sand and silt with trace clay is encountered below the sand unit at 23 and 22 feet bgs, respectively. Based on field observations, it is interpreted as an aquitard beneath Building 292. The thickness of this aquitard is unknown. The lateral extent is marked to the north by S57MW012 and to the south by S57MW007. At locations S57MW012, S57MW007, and S57MW009, a brown and olive gray clay and silt are encountered at 43, 27, and 19 feet bgs, respectively.

This clay unit extends the length of the cross-section, with the clay content increasing toward the north. Based on field observations, it is interpreted as an aquitard.

Cross-Section B-B′

Cross-section B-B′ (Figure 1-7) is a southern continuation of cross-section A-A′. It is a northwest to southeast transect looking northeastward that depicts the subsurface materials along the southern portion of the study area in the vicinity of the former Building 158 and extending beyond outfall IW-80 to Mattawoman Creek. Fill material is encountered at locations S57MW009/010 and S57MW020 from the ground surface to 11 and 9 feet bgs, respectively. The fill material at S57TW021 is interpreted to be the storm sewer bedding. The yellow-brown and gray sand unit is encountered below the fill material and at the surface when the fill is absent. The sand unit contains more gravel near the ground surface where it is exposed at the ground surface between S57MW010 and S57CP003. At S57CP003, a 9-foot-thick clay lens was encountered at approximately 6 feet bgs, and a clay layer was encountered at the ground surface extending down 4 feet. It is interpreted that these shallow clay units are not part of the lower clay and silt aquitard. The lower clay and silt aquitard encountered at S57MW007 on cross-section A–A′ is encountered at location S57MW009 and extends nearly the length of the cross-section. However, at S57CP003 (located outside the stream valley), the unit is interpreted to become a clayey sand unit with an approximate thickness of 20 feet. Based on field observations, this clayey sand unit has low permeability and is considered to be an aquitard. Farther south, the clayey sand gives way to the clay unit, which thins to approximately 2 feet at S57SB031 and S57TW021 and grades into a soft and more permeable clayey silt with peat at S57MW022. The clayey sand underlying the peat unit at S57MW022 is a poor aquitard based on field observations.

Cross-Section C-C′

Cross-section C-C′ (Figure 1-7) is a north to south transect looking eastward that depicts the subsurface materials between Site 57, Former Drum Loading Area and Building 292 (lowland) and the uplands to the south toward Mattawoman Creek. Fill material is encountered at locations S57MW001/002 and S57TW016/017. The yellow-brown and gray sand unit is encountered below the fill material and at the surface when the fill is absent. The sand unit contains more gravel near the ground surface and extends the entire length of the cross-section. The clayey sand and silt aquitard lens encountered at S57MW001/002 on cross-section A–A′, extends to S57TW016/017. Further south, outside the lowland area at S57CP001, a clayey sand unit is encountered at 26 feet bgs; it is at least 17 feet thick. Based on field observations, this clayey sand unit has low permeability, extends the length of the section, and is interlayered with sandy clay lenses.

Cross-Section D-D′

Cross-section D-D′ (Figure 1-8) is a north to south transect looking eastward that depicts the subsurface materials between the southern portion of the study area in the vicinity of the former Building 157 and Mattawoman Creek. At locations S57SB030 and S57SB031, silty sand and gravel were encountered at the ground surface, extending down to approximately 7 to 10 feet bgs. The silty sand and gravel may be reworked natural material used for the development of the roads and buildings in the immediate vicinity. The yellow-brown and gray sand unit is encountered below the silty sand gravel and extends to the south beyond S57CP007, where it grades into a clayey sand layer at 41GW03 and 41GW04. The brown olive gray clay and silt unit was encountered beneath the yellow brown sand unit at soil borings S57SB030 and S57SB031 (where the unit is approximately 2 feet thick). Farther south, the clay layer was found at S57SB032 to be at least 14 feet thick; it extends the remainder of the cross-section south to Mattawoman Creek. However, the clay unit grades into a clayey sand unit in the upland area at S57CP007 and, based on field observations, the clayey sand unit is an aquitard.

Cross-Section E-E′

Cross-section E-E′ (Figure 1-8) is a west to east transect looking northward that depicts the subsurface materials along Mattawoman Creek downgradient of the study area. Fill material is encountered across most of the cross-section except at S57CP008. A clayey sand unit was encountered beneath the fill material at locations 41MW01, 41SB01 and 41GW04 and at the ground surface at S57CP008. At locations 41MW02 and S57CP008, an 8- and 2-feet-thick layer of sand underlies the fill material and the sand layer pinches out to the east at S57MW022. At S57CP008, the sandy clay lens encountered at approximately 20 feet bgs is inferred to be part of the aquitard in this area. It grades into a brown olive-gray clay layer to the east at 41GW01 and extends beyond 41GW04, where it pinches out or grades into a clayey sand that extends the length of the cross-section to the east.

1.3.4 Site Hydrogeology

The surficial aquifer in the yellow-brown sand unit and fill beneath the study area display the characteristics of an unconfined system. The depth to the static water level in completed wells ranged from 3.6 to 11.5 feet bgs. The olive-brown silt and clay aquitard beneath the surficial aquifer would hinder the downward movement of groundwater from the surficial aquifer to deeper aquifers. However, as shown on the cross-sections, where the olive-brown silt and clay aquitard becomes sandier or thinner, it would provide less hindrance to downward groundwater flow.

One complete round of water-level measurements was collected from the 16 monitoring wells and seven temporary wells on August 29, 2001. The synoptic groundwater-level measurement was performed to determine the groundwater flow pattern at the site. Measurements were taken with an electronic water-level indicator (M-scope) using the top of the well riser pipe as the reference point for determining depths to water. Groundwater-level measurements were recorded on a groundwater-level measurement form to the nearest 0.01 foot. Table 1-1 provides a summary of the water-level data used to generate the potentiometric surface map (Figure 1-9).

Based on the potentiometric surface map, the groundwater in the upper and lower portions of the surficial aquifer is flowing southeast toward the intermittent stream (unnamed stream) and southeast toward Mattawoman Creek. There is a slight downward flow component in the northern portion of the study area based on water levels measured at well cluster S57MW012/013. There is a very slight upward flow component in the southern portion of the study area based on water levels measured at well cluster S57MW005/006. The upper surficial groundwater may be discharging to both the unnamed stream and Mattawoman Creek. The lower groundwater in the surficial aquifer is most likely discharging to Mattawoman Creek and, to a lesser degree, possibly to the unnamed stream. The surficial aquifer is recharged by infiltration of precipitation through the vadose zone and by groundwater flowing from the adjacent upland areas located to the north, east, and west.

The results of a tidal study showed that there is a tidal influence of approximately 0.5 foot on the groundwater at well S57TW003, which is located approximately 200 feet from Mattawoman Creek. The groundwater flow pattern at Site 57 is unlikely to be affected by the tidal fluctuations because the site is located at a higher elevation and approximately 1,300 feet from the creek.

Based on slug test data, the geometric mean hydraulic conductivity was 2.3 feet per day for the shallow monitoring wells and 2.3 feet per day for the deep monitoring wells. The resulting geometric mean value for the study area was 2.3 feet per day. Table 1-2 provides a summary of the slug test results. The hydraulic gradient was estimated to be 0.04 foot per foot in the northern portion of the study area, including Building 292. The hydraulic gradient was also estimated in the southern portion of the site to be 0.022 foot per foot. Based on an estimated effective porosity of 0.25, the seepage velocity of the groundwater beneath Site 57 (in the northern portion of the study area) is estimated to be 0.37 foot per day. The seepage velocity of the groundwater in the southern portion of the study area is estimated to be 0.20 foot per day. The differences in these seepage velocities are caused by the different hydraulic gradients in the northern and southern portions of the study area.

1.3.5 Historical Environmental Data

TCE, at a concentration of 53 micrograms per liter (µg/L), was first detected from Site 57 in February 1994 at the industrial wastewater/stormwater outfall (designated IW-80), which was investigated in response to an odor (Figure 1-10). This outfall is approximately 1,300 feet downgradient from Building

292 and serves the drainage basin that includes Building 292. A sample collected from the same location in May 1994 contained TCE at a concentration of 60.2 µg/L. The Navy conducted additional rounds of storm sewer sampling and analysis for TCE in an attempt to locate the source of this chemical. Sample results from July 1994 did not detect TCE or any other volatile organic priority pollutants upstream of Building 292 (Sampling Points 1, 2, and 3 on Figure 1-10). However, TCE was detected at manhole MH-1 (62 µg/L) immediately downgradient of the building and more than 1,300 feet downstream from the building at IW-80 (47 µg/L) (Sampling Points 4 and 5 on Figure 1-9). No other volatile organic priority pollutant was outfall detected.

A soil-gas survey was conducted in September 1995. The soil-gas sampling locations and field TCE analytical results are shown on Figure 1-11. The location with the highest concentration (9,600 µg/L) SG-07, was near the southern corner of Building 292, near where drums were filled and stored. Other locations with elevated concentrations were SG-02 (3,200 µg/L) and SG-10 (2,500 µg/L). The concentrations generally decreased with distance from the building.

Nine subsurface soil samples were collected from four locations in 1995, based on the results of the soil-gas survey. TCE was detected at concentrations of 840,000 micrograms per kilogram (µg/kg) and 9,300 µg/kg in samples collected from 2 to 4 feet bgs near the southern corner of Building 292. Lower concentrations of 1,2-dichloroethene and 1,1,1-trichloroethane were also detected at this depth interval. Chemical concentrations were much lower in samples collected from 10 to 12 feet bgs. Consistent with the soil-gas measurements, the concentrations decreased with distance from Building 292. Technical-grade TCE contains 3.5 percent by weight of 1,1,1-trichoroethane, and 1,2-dichloroethene is a degradation product of TCE.

Two groundwater samples were collected in 1995 based on the results of the soil-gas survey. TCE was detected at a concentration of 370,000 µg/L in the groundwater sample collected near the southern corner of Building 292. The concentration of 1,2-dichloroethene was 52,000 µg/L. Lower concentrations of 1,1,1-trichloroethane, its degradation products, and TCE degradation products were detected at this location. TCE was detected at a concentration of 3 µg/L in the groundwater sample collected 175 feet south of the building.

Two water samples were collected from two pipes in manhole MH-1 in 1995. TCE was detected at concentrations of 2 µg/L and 39 µg/L. The concentration of 1,2-dichloroethene was 7 µg/L in one sample, but was not detected in the other sample.

The sewer line was relined between manholes MH-427 and MH-487 in 1998 (see Figure 1-4).

The RI was conducted in October 1998 and January 1999 to further delineate the nature and extent of contamination. The field investigation, analytical results, and human health and environmental risk assessments are fully described in the RI Report (TtNUS, 2000). The field activities included the collection of 10 surface soil samples, 38 subsurface soil samples, 17 groundwater samples, 20 surface water samples, and eight sediment samples. Groundwater samples were collected from upper surficial wells, lower surficial wells, and a potable water well. Some surface water and sediment samples were collected from the storm sewer and others were collected from open channels. Soil and sediment samples were analyzed for Target Compound List (TCL) volatile organic compounds (VOCs) and diethyl ether. Selected soil and sediment samples were also analyzed for TCL semivolatile organic compounds (SVOCs), TCL pesticides/polychlorinated biphenyls (PCBs), explosives, and total organic carbon (TOC). Selected sediment samples were also analyzed for acid volatile sulfides/simultaneously extracted metals (AVS/SEM). Aqueous samples were analyzed for TCL VOCs and diethyl ether. Selected aqueous samples were analyzed for the full list of TCL and TAL compounds, cyanide, explosives, hardness, and ecological parameters. Both filtered and unfiltered groundwater samples were analyzed for TAL metals.

1.3.6 Nature and Extent of Contamination

The following is a summary of the nature and extent of contamination at Site 57, as presented in the RI Report (TtNUS, 2000).

- Minimal organic contamination is present in soil, groundwater, surface water, and sediment upgradient of Site 57. Diethyl ether, a site-related VOC, was detected in the upgradient surface soil sample (54 µg/kg) and the lower surficial upgradient groundwater sample (3.6 µg/L). Nitrocellulose was detected in the upgradient surface soil sample (50,400 µg/kg) and the lower surficial upgradient groundwater sample (223 µg/L). TCE, another site-related VOC, and several other chlorinated VOCs were detected in the upper surficial and lower surficial upgradient groundwater samples. However, with the exception of 1,1-dichloroethene in the upper surficial upgradient groundwater sample (77.5 µg/L), concentrations of the chlorinated hydrocarbons in the upgradient groundwater samples were relatively low, ranging from 0.8 µg/L to 14.6 µg/L. No organic compounds were detected in the upgradient surface water and sediment samples.

- TCE and several chlorinated hydrocarbons were detected in downgradient soil and groundwater samples. TCE and one of its degradation products, 1,2-dichloroethene, were typically detected with the greatest frequency and at the highest concentrations. Notable concentrations of TCE at 220,000 µg/kg and cis-1,2-dichloroethene at 77,000 µg/kg were detected in a subsurface soil sample collected near the southern corner of Building 292. Most of the positive results for TCE in subsurface soil were associated with samples collected within 100 feet of the former drum loading area. TCE and cis-1,2-dichloroethene, at maximum concentrations of 93 µg/kg and 4 µg/kg, respectively, were the only chlorinated hydrocarbons detected in the surface soil samples.

- The concentrations of the VOCs cis-1,2-dichloroethene, methylene, chloride, and TCE in several subsurface soil samples were higher than EPA and state screening levels for migration of chemicals from soil to groundwater. However, methylene chloride was not detected in any groundwater samples.

- Maximum concentrations of TCE and several other chlorinated hydrocarbons in upper surficial groundwater samples were associated with monitoring well S57MW004, located at the southeastern corner of Building 292. Maximum concentrations of all detected chlorinated hydrocarbons except vinyl chloride in lower surficial groundwater samples were associated with well S57MW009, located between the railroad tracks and Thomas Road and approximately 450 feet downgradient of Building 292. However, definitive patterns (i.e., from upgradient to downgradient or from upper surficial to lower surficial) of chlorinated hydrocarbon contamination in upper and lower surficial groundwater could not be identified.

- Although not detected in downgradient surface soil, subsurface soil, open channel surface water, or open channel sediment, diethyl ether was frequently detected in downgradient upper and lower surficial groundwater, storm sewer surface water, and storm sewer sediment. The maximum concentrations of diethyl ether associated with upper and lower surficial groundwater were 3,950 µg/L and 1,930.6 µg/L, respectively. The highest concentrations of diethyl ether in the groundwater samples were found in the area near or within 300 feet of Building 496, a vault used for the storage of ether. The maximum diethyl ether concentration (3,950 µg/L at well S57MW011) was detected approximately 100 feet south of Building 292. In general, diethyl ether concentrations in groundwater decreased with downgradient distance from Building 292. Diethyl ether concentrations in storm sewer water and sediment samples at the outfall to Mattawoman Creek were 70.2 µg/L and 14 µg/kg, respectively.

- Very few SVOCs were detected in Site 57 groundwater or surface water samples. Several SVOCs, primarily polynuclear aromatic hydrocarbons (PAHs), were sporadically detected in downgradient surface and subsurface soil samples. The maximum concentrations of all SVOCs in soil samples were associated with the samples collected from boring S57MW009/SB005, located approximately 400 feet southeast of Building 292 between the railroad tracks and Thomas Road. PAH concentrations in soil samples at this location ranged from 37 µg/kg to 4,200 µg/kg for surface soil and from 60 µg/kg to 510 µ/kg for subsurface soil. The presence of PAHs at this location may be related to the past and current use of gasoline-fueled vehicles, asphalt associated with Thomas

Road, and/or the use of creosote as a preservative for railroad ties. Several PAHs were also detected in the sediment sample collected at the drainage channel outlet into the unnamed creek and in the sediment sample collected at the storm sewer outfall at Mattawoman Creek.

- Although not detected in open channel or storm sewer sediment samples, nitrocellulose was detected in a majority of the downgradient surface soil, subsurface soil, groundwater, and surface water samples analyzed for this chemical. Concentrations in downgradient surface soil samples ranged from 116,000 µg/kg at boring S57MW011/SB008 to 299,000 µg/kg at boring S57MW009/SB005. Concentrations in downgradient subsurface soil samples ranged from 66,000 µg/kg at boring S57MW011/SB008 (4 to 6 feet bgs) to 205,000 µg/kg at boring S57MW011/SB008 (10 to 11 feet bgs). A definitive pattern of nitrocellulose contamination in relation to soil depth could not be determined. Nitrocellulose was detected at a concentration of 148 µg/L in both an upper surficial and alower surficial groundwater sample and at a concentration of 221 µg/L in an open channel surface water sample. Nitrocellulose was detected in storm sewer surface water samples at concentrations ranging from 114 µg/L to 1,230 µg/L. Concentrations increased with downgradient distance.

- In general, detected concentrations of inorganics in all media do not appear to vary greatly between upgradient and downgradient, surface and subsurface, or upper surficial and lower surficial samples. Most of the detected concentrations of metals in all media were less than facility background concentrations. Notable detections of metals include lead [487 milligrams per kilogram (mg/kg)] in the surface soil sample collected from boring S57MW009/SB005 located approximately 400 feet south of Building 292 and arsenic (103 mg/kg) in the surface soil sample collected from boring S57SB007, located approximately 20 feet south of Building 292.

- Arsenic was detected in soil at a concentration higher than EPA and state screening levels for migration of chemicals from soil to groundwater; however, arsenic was not detected in any groundwater samples.

- TCE was detected at a concentration of 7.2 µg/L in the sample collected from potable well PW-07. This well is located downgradient of Site 57. No other VOCs were detected in this sample. TCE was not detected when this well was resampled in October 1999. Based on the geologic cross-sections, geologic formations and conditions encountered during soil boring installation and cone penetrometer testing, water-level measurements, and potentiometric surface map, Site 57 does not appear to be the source of TCE detected in well PW-07.

- Dlethyl ether (69.4 µg/L), TCE (16.5 µg/L), cis-1,2-dichloroethene (40.1 µg/L), and vinyl chloride (3.5 µg/L) were detected in the surface water sample collected from Mattawoman Creek downgradient of the Site 57 storm sewer outfall. Diethyl ether (7 µg/kg) and cis-1,2-dichloroethene (4 µg/kg) were also detected in sediment at this location. The results indicate that chemicals from Site 57 may be migrating to Mattawoman Creek.

1.3.7 Contaminant Fate and Transport

The analytical data for Site 57 indicate that organic chemicals have migrated from the source area to downgradient soil, groundwater, surface water, and sediment. VOCs (e.g., TCE and cis-1,2-dichloroethene) were detected in surface and subsurface soil. VOC concentrations were higher in subsurface soil than surface soil. The detection of VOCs in groundwater samples indicates the chemicals have migrated from soil to groundwater. TCE and cis-1,2-dichloroethene were detected in surface water samples from the unnamed stream. As discussed in Section 1.3.4, shallow groundwater may be discharging to this stream, and groundwater may be the source of these detections. Several VOCs (e.g., 1,1,1-trichloroethane, 1,1-dichloroethene, acetone, diethyl ether, toluene, cis-1,2-dichloroethene, trans-1,2-dichloroethene, and vinyl chloride) were detected in groundwater samples and storm sewer water samples. This suggests that groundwater may be infiltrating into the storm sewer. However, several VOCs (2-butanone, bromodichloromethane, bromoform, dibromochloromethane, ethylbenzene, and styrene) were detected in storm sewer samples but not in soil or groundwater samples, suggesting another source of these chemicals.

The degradation products for TCE include cis-1,2-dichloroethene, 1,1-dichloroethene, trans-1,2-dichloroethene, and vinyl chloride, among others. TCE was detected in 11 of the 14 upper and lower surficial groundwater samples collected during the RI. Cis-1,2-dichloroethene was found in 12 of the 14 samples. Other detected degradation products included 1,1-dichloroethene (seven of 14 samples), trans-1,2-dichloroethene (four of 14 samples), and vinyl chloride (six of 14 samples). In addition, technical-grade TCE contains 1,1,1-trichloroethane, which was detected in eight of 14 samples. 1,1-Dichloroethane, a degradation product of 1,1,1-trichloroethane, was detected in eight of 14 samples.

With the exception of S57MW004 (at the southern corner of Building 292), the highest concentration of cis-1,2-dichloroethene (260 µg/L) occurred at well S57TW003, the most downgradient sampling location. This location also had the highest concentration of vinyl chloride (85 µg/L). The presence of TCE degradation products in a large number of groundwater samples and their occurrence at relatively significant concentrations at the farthest downgradient location suggest that natural attenuation of TCE in the groundwater may be taking place.

Concentrations of inorganics were typically within background levels for surface soil, subsurface soil, groundwater, and sediment. Concentrations in upgradient samples were comparable to those in downgradient samples. This suggests that inorganics are not migrating from the source area at the site.

1.3.8 Human Health Risk Assessment Summary

A baseline risk assessment was developed for Site 57 in the RI Report. The baseline risk assessment identifies chemicals of potential concern (COPCs) and develops carcinogenic and non-carcinogenic risk estimates. Tables have been extracted from the RI and included in this FS to provide a summary of the baseline risk assessment. Tables 1-3, 1-4, and 1-5 summarize the COPCs in the upgradient area, downgradient area, and sewer, respectively, for surface soil, subsurface soil, shallow groundwater, deep groundwater, surface water, sediment, migration of soil contaminants to air, and migration of soil contaminants to groundwater. Tables 1-6 through 1-9 summarize estimated cancer and non-cancer risks for the upgradient and downgradient areas for the reasonable maximum exposure (RME) and central tendency exposure (CTE). Table 1-10 is a summary of risks associated with exposure to surface water and sediment in the storm sewer. Additional information on the procedures followed to develop the human health risk assessment is provided in the RI Report (TtNUS, 2000). The following discussion is a summary of the human health risk assessment for Site 57. Unacceptable risks were identified for future construction workers exposed to soil and hypothetical future residents exposed to soil and groundwater.

- The human health risk assessment considered current and future full-time employees exposed to surface soil and future construction workers and hypothetical future residents exposed to surface and subsurface soil, groundwater, surface water, and sediment. Both RME and CTE scenarios were evaluated. Exposures to current and future adolescent trespassers were not considered because the site is located in a secure area.

- No COPCs were identified for upgradient surface water and sediment; consequently, no adverse health effects are anticipated for exposure to these media.

- Incremental cancer risks for the full-time employee exposed to surface soil under the RME and CTE scenarios in the upgradient and downgradient areas were within or less than the EPA target risk range of 1E-04 to 1E-06.

- Hazard indices for the full-time employee exposed to surface soil under the RME and CTE scenarios in the upgradient and downgradient areas were less than 1.0. This indicates that there is minimal potential for adverse health effects under the conditions established in the risk assessment.

- The excess lifetime cancer risks for the future construction worker under the RME and CTE scenarios exposed to surface/subsurface soil and groundwater in the upgradient area, surface/subsurface soil, groundwater, surface water, and sediment in the downgradient area, and surface water and sediment in the storm sewer were within or less than the EPA target risk range of 1E-04 to 1E-06.

- The hazard indices for a construction worker exposed to surface/subsurface soil and groundwater in the upgradient area and surface water and sediment in the storm sewer were less than 1.0 for the RME and CTE scenarios.

- The hazard indices for a construction worker exposed to surface/subsurface soil, groundwater, surface water, and sediment in the downgradient area exceeded 1.0 for the RME scenario. Incidental ingestion of arsenic in surface/subsurface soil was the main contributor to the hazard index. Elevated concentrations of arsenic were limited to boring S57SB007. If the results for these samples were removed from the database, the hazard index for construction workers exposed to all media in the downgradient area would be less than the acceptable level of 1.0. The hazard index for the construction worker under the CTE scenario was less than 1.0.

- The excess lifetime cancer risk for a lifelong resident exposed to surface/subsurface soil and groundwater in the upgradient area exceeded the EPA target risk range of 1E-04 to 1E-06 for the RME scenario. Potential exposure to 1,1-dichloroethene in groundwater was the main contributor to the cancer risk. The excess lifetime cancer risk for a lifelong resident under the CTE scenario was within the EPA target risk range.

- The total cumulative hazard index for a hypothetical child resident exposed to surface/subsurface soil and groundwater in the upgradient area exceeds the acceptable level of 1.0. However, the hazard index per target organ was less than 1.0, which indicates that there is minimal potential risk for adverse health effects under the conditions established in the risk assessment. The hazard index for the child resident under the CTE scenario was less than 1.0.

- The total cumulative hazard index for a hypothetical adult resident exposed to surface/subsurface soil and groundwater in the upgradient area under the RME and CTE scenarios were less than the acceptable level of 1.0.

- The excess lifetime cancer risk for a lifelong resident exposure to surface/subsurface soil, groundwater, surface water, and sediment in the downgradient area exceeded the EPA target risk range of 1E-04 to 1E-06 for the RME and CTE scenarios. Incidental ingestion of arsenic in soil, ingestion of TCE in groundwater, and ingestion and inhalation of vinyl chloride in groundwater were the main contributors to the cancer risk.

- The total cumulative hazard indices for hypothetical future child and adult residents exposed to surface/subsurface soil, groundwater, surface water, and sediment in the downgradient area exceeded the acceptable level of 1.0 for the RME and CTE scenarios. Incidental ingestion of arsenic in soil and ingestion of cis-1,2-dichloroethene, diethyl ether, and TCE in groundwater were the main contributors to the hazard index for the child resident. Ingestion of cis-1,2-dichloroethene and TCE in groundwater was the main contributor to the hazard index for the adult resident.

- Incremental cancer risks for a lifelong resident exposed to groundwater from well PW-7 under the RME and CTE scenarios were within the EPA target risk range of 1E-04 to 1E-06.

- Hazard indices for hypothetical child and adult residents exposed to groundwater from well PW-7 under the RME and CTE scenarios were less than 1.0.

- The maximum detected concentration of lead in downgradient subsurface soil exceeded the EPA Office of Solid Waste and Emergency Response (OSWER) residential screening level of 400 mg/kg. The Integrated Exposure Uptake Biokinetic (IEUBK) model was used to evaluate exposures to lead in soil by hypothetical residential children. The IEUBK model indicated that no adverse effects are anticipated for hypothetical future child residents exposed to lead in soil.

Contaminants of concern (COCs) are based on protection of human health, protection of the environment, and/or exceedances of regulatory standards (e.g., drinking water standards). The only soil COC based on protection of human health is arsenic. Soil COCs based on protection of groundwater are cis-1,2-dichloroethene and TCE. Groundwater COCs based on protection of human health and/or exceedance of a regulatory standard include 1,1-dichloroethene, cis-1,2-dichloroethene, diethyl ether, tetrachloroethene, trichloroethene, and vinyl chloride. There are no COCs for surface water or sediment. There is no unacceptable risks to human health or exceedance of regulatory standards for surface water or sediment.

1.3.9 Ecological Risk Assessment Summary

The areas near Building 292 that could have received surface contamination are mainly covered with asphalt and gravel, providing no terrestrial habitat. Runoff from the potentially impacted areas near the building would flow southward into a ditch lined with a half-round metal pipe. The only potentially impacted area of ecological concern near the building is a patch of mowed turfgrass, approximately 100 feet long by 30 feet wide, that is surrounded on all sides by concrete. For these reasons, the potential for ecological risks on and near the site proper (surface soil and related terrestrial risks) is negligible. Potential ecological risks could be present in downstream portions of the unnamed tributary and Mattawoman Creek that receive stormwater runoff from the site.

Several chemicals were detected in the sewer near Site 57, the downgradient ditches and stream, and Mattawoman Creek where the sewer and stream discharge. For the most part, chemical concentrations in surface water and sediment in these areas were relatively low and indicative of low potential ecological risks. The exceptions are potential risks from copper in sewer water, sewer sediment, and Mattawoman Creek sediment and from mercury in Mattawoman Creek and downgradient sediment. VOCs were elevated in almost all media assessed in the ecological risk assessment (ERA). Although VOCs are not generally associated with ecotoxicity, their elevated concentrations could be of concern. It is unclear whether activities at Building 292 have contributed copper and mercury to the environment, although this does not appear to be the case. The recent cleaning of the sewer suggests that sewer sediment is no longer a source of chemicals to downgradient areas, including Mattawoman Creek. However, because of the elevated concentrations of some chemicals in Mattawoman Creek near the stream and sewer discharge points, this area will be studied further as part of the Mattawoman Creek Environmental Risk Assessment Study.

1.3.10 Pre-Feasibility Study Investigation

This section describes the pre-FS field activities that were conducted in August 2001. The field activities were conducted to fill data gaps, refine the nature and extent of soil and groundwater contamination, and refine subsurface characteristics. Field activities at Site 57 included installation of soil borings, temporary monitoring wells, and permanent monitoring wells, soil sampling, groundwater sampling, cone penetrometer testing, and aquifer testing. Sampling locations are shown on Figures 1-5 and 1-12. Field forms including boring logs, well construction sheets, well completion reports, well development sheets, sample log sheets, chain-of-custody forms, water-level measurements, and survey data are included in Appendix A. The laboratory analytical data are included in Appendix B. Data validation memoranda are included in Appendix C. Aquifer test measurements and calculations are included in Appendix D. The cone penetration testing report is included in Appendix E.

1.3.10.1 Soil Sampling

Eighteen soil borings were installed to collect soil samples. Some of the borings were converted into temporary or permanent monitoring wells. Table 1-11 provides a summary of the soil sampling and analysis program. A summary of positive analytical results is provided in Table 1-10.

Soil borings S57SB016 through S57SB025 (Figure 1-12) were installed in the source area near Building 292 to refine the extent of soil contaminated with arsenic and chlorinated solvents. This is the area where exposure to arsenic in soil could pose unacceptable risks to human health under residential and industrial exposure scenarios. This is also the area where previously detected concentrations of cis-1,2-dichloroethene and TCE indicate a potential source of ongoing groundwater contamination.

Surface and subsurface soil samples were collected from the borings. Most samples were analyzed for TCL VOCs and ethyl ether, and many samples were analyzed for arsenic. Some of the subsurface soil samples were analyzed for engineering parameters including TOC, cation exchange capacity, pH, grain size, and bulk density. Arsenic was detected in surface and subsurface soil samples to a depth of 5 feet bgs at concentrations ranging from 2.3 to 79.9 mg/kg. Cis-1,2-dichloroethene (12 to 690 µg/kg) and TCE (5.5 to 270 µg/kg) were detected in surface and subsurface soil samples. Most of the detections in subsurface soil samples were detected at a depth of 4 to 5 feet bgs. These VOCs were infrequently detected at deeper sampling intervals (8 to 10 feet and 14 to 16 feet bgs). The positive detections for the COCs arsenic, cis-1,2-dichloroethene, and TCE in surface soil are shown on Figure 1-13. The positive detections for these COCs in subsurface soil are shown on Figure 1-14. These figures also show the positive detections from the sampling conducted during the RI.

Soil boring S57SB026 (Figure 1-5) was installed to evaluate upgradient conditions. A subsurface soil sample was analyzed for TOC.

Soil borings S57SB027 through S57SB029 (Figure 1-5) were installed upgradient, sidegradient, and downgradient of the source area to refine the extent of chlorinated solvent contamination. Surface and subsurface soil samples were collected and analyzed for TCL VOCs and ethyl ether. These borings were converted into temporary monitoring wells. TCL VOCs, including the soil COCs cis-1,2-dichloroethene and TCE, were not detected in any surface or subsurface soil samples collected from these borings. Ethyl ether was detected in a few subsurface soil samples that corresponded to the locations where ethyl ether was detected in groundwater during the RI and pre-FS investigations.

Soil borings S57SB030 through S57SB032 (Figure 1-5) were installed farther downgradient of the source area to determine whether chlorinated solvent contamination was present. Subsurface soil samples were collected and analyzed for TCL VOCs and ethyl ether. Selected subsurface soil samples were also analyzed for engineering parameters. TCL VOCs and ethyl ether were not detected in any of the subsurface soil samples collected from these borings.

Soil boring S57SB033 (Figure 1-5) was installed near potable water well PW-7 where TCE was detected during a previous sampling round. A subsurface soil sample was analyzed for TCL VOCs and ethyl ether. This boring was converted into a permanent monitoring well. The only VOC that was detected was methylene chloride.

The soil sampling conducted during the pre-FS investigation resulted in further delineation of the extent of arsenic, cis-1,2-dichloroethene, and TCE contamination in soil. These are the only soil COCs for Site 57.

The pre-FS investigation did not identify any other COCs for soil based on protection of human health or protection of groundwater.

1.3.10.2 Groundwater Sampling

Ten new monitoring wells were installed in the upper and lower portions of the surficial aquifer to collect groundwater samples to better define the extent of groundwater contamination and to gather information to allow for an evaluation of natural attenuation processes that may be occurring. The wells were temporary wells S57TW014 through S57TW019 and S57TW021 and permanent wells S57MW020, S57MW022, and S57MW023. Samples were collected from the new and existing monitoring wells. Table 1-13 provides a summary of the monitoring well construction details for the new and existing wells. All groundwater samples were analyzed for TCL VOCs and ethyl ether (diethyl ether). Many of the samples were also analyzed for water chemistry parameters and parameters that would allow for an evaluation of natural attenuation. A summary of positive analytical results is provided in Table 1-14.

There are five groundwater areas that have different characteristics and chemical concentrations. These include the upgradient area, source area, mid-plume area, and downgradient area. There is an area between the mid-plume and downgradient areas where little or no contamination was detected.

The upgradient area is northeast of Building 292 and includes well clusters S57MW012/MW013 and S57TW014/TW015. With the exception of 1,1-dichloroethene (74 μg/L) at location S57MW013 and diethyl ether (920 μg/L) and tetrachloroethene (7.1 μg/L) at location S57TW015, the concentrations of chlorinated VOCs were generally less than 5 μg/L.

The source area begins near Building 292 near well cluster S57MW001/MW002 and extends approximately 400 feet down the valley to well clusters S57MW007/MW008 and S57TW018/TW019. The results of the 2001 pre-FS sampling are similar to those from the 1999 RI sampling. The chemicals detected most frequently and at the highest concentrations were TCE, cis-1,2-dichloroethene, and diethyl ether. TCE concentrations ranged from not detected at wells S57MW001, S57MW008, and S57TW016 to a maximum concentration of 12,000 μg/L at well S57MW004. Well S57MW004, which is screened in the upper portion of the surficial aquifer, is located near Building 292, where drums of spent TCE were stored. The sample from well S57MW004 also had the highest concentration of cis-1,2-dichloroethene (620 (μg/L). The sample for well S57MW003, which is the deeper well at this location, had 365 μg/L of TCE and 30 μg/L of cis-1,2-dichloroethene. The concentrations of cis-1,2-dichloroethene in other wells ranged from not detected at locations S57MW001, S57MW008, S57TW016, and S57TW017 to 66 μg/L at well S57TW018. The concentrations of diethyl ether ranged from 2.1 μg/L at well S57TW018 to 4,800 μg/L at well S57TW017. Well S57TW017 is located near Ether Vault No. 4 (Building 496). Other chemicals detected less frequently and at lower concentrations were 1,1-dichloroethene, tetrachloroethene, and vinyl chloride.

The mid-plume area is southeast of the source area and includes well clusters S57MW005/MW006 and S57MW009/MW010. This area extends approximately 500 feet down the valley. The chemicals detected in this area are similar to those detected in the source area but generally at lower concentrations. However, the concentrations of 1,1-dichloroethene were slightly higher than in the source area. TCE concentrations ranged from not detected at well S57MW005 to 480 µg/L at location S57MW009. The concentration of cis-1,2-dichloroethene ranged from not detected at well S57MW005 to 150 µg/L at well S57MW010. Diethyl ether was only detected at well S57MW005 at a concentration of 570 µg/L.

Farther southeast of the mid-plume area is a zone where minimal groundwater contamination was detected. This area includes shallow wells S57MW020 and S57TW021 and extends approximately 600 feet down the valley from the mid-plume area. Chlorinated VOCs were not detected in either of these wells. Diethyl ether was detected at well S57MW020 at a concentration of 18 µg/L. No wells were installed in the deeper portion of the surficial aquifer in this area; however, groundwater contamination was detected downgradient of this area, as discussed below. This creates uncertainty in defining the overall extent of groundwater contamination.

The downgradient area is near shallow wells S57TW003 (installed and removed in 1999) and S57MW022. This area also includes cone penetrometer location S57CP005, which extended into the deeper portion of the aquifer. The contamination in this area is not as well defined as in the source area and the mid-plume area. TCE and diethyl ether were not detected in the shallow wells but were detected at concentrations of 11 µg/L and 800 µg/L, respectively, at S57CP005. Well S57MW022 exhibited the highest concentrations of cis-1,2-dichloroethene (1,400 µg/L) and vinyl chloride (1,500 µg/L).

The presence of TCE degradation products in a large number of groundwater samples and their occurrence at relatively significant concentrations at the most downgradient location suggest that natural attenuation of TCE in the groundwater may be taking place.

Well S57MW023 was installed in the surficial aquifer near potable well PW-07 where TCE was detected in a sample collected in 1997 (but not in 1999). Benzene (900 µg/L), o-xylene (28 µg/L), and TCE (30 µg/L) were detected in the groundwater sample from well S57MW023. Benzene and o-xylene have never been detected in any of the groundwater samples associated with Site 57. This provides further evidence that Site 57 is not the source of the TCE that was previously detected in potable well PW-07.

1.3.10.3 Cone Penetrometer Tests

Piezoelectric cone penetration tests (P-CPT) were conducted at 10 locations as part of the pre-FS field investigation. The subcontractor, Applied Research Associates, Inc., conducted the P-CPTs under the supervision of a Maryland-licensed driller from Chesapeake Geosystems, Inc. and TtNUS geoscientist. The purpose of the P-CPT was to better characterize the geology and extent of groundwater contamination at the site. Typically, two tests (penetrations) were conducted at each location. The first test was a P-CPT to generate a geologic profile, and the second was conducted to collect a groundwater sample at a specific depth based on the preliminary findings of the first penetration. The resulting geologic profiles from the P-CPT were used in combination with soil boring logs to generate generalized geologic cross-sections to illustrate the subsurface materials. Dissipation tests were also conducted during the P-CPT that may provide information about the permeability, depth to the water table, and compressibility of the formation.

Well points were installed at seven of the 10 P-CPT locations. Three of the well points were dry, and four were sampled for VOC analysis. The groundwater samples were collected using a stainless-steel bailer. At three of the 10 P-CPT locations, well points were not installed because the P-CPT parameters indicated that the formation of sandy silt and clay mix was more than 10 feet thick.

1.3.10.4 Aquifer Testing

Slug tests were completed at 16 permanent wells and seven temporary wells to estimate the horizontal hydraulic conductivity (k_h) of the aquifer in accordance with the procedures provided in Section 2.7.1 of the master field sampling plan (FSP).

Rising head slug tests were performed at the permanent wells. The change in water level at the permanent wells was induced by withdrawing two bailers (each with a volume of 1 liter) simultaneously. Rising head slug tests were also performed at four temporary wells using a solid (1/2 inch in diameter by 6 feet long) galvanized steel slug to induce the water-level change. Falling head slug tests were performed at the temporary wells by introducing a 1-liter slug of deionized water into the well. Before a slug test was initiated, the static water level in the monitoring well was measured using an electronic water-level indicator. Water levels were recorded with a pressure transducer at logarithmic intervals of time using a programmed electronic data logger as the head returned to the original static water level. The time and the rate of change required for the water level to return to the original static water level are functions of the transmissivity of the aquifer.

1.3.10.5 Surveying

The monitoring well (temporary and permanent), P-CPT, and soil borings locations were surveyed by the firm of Donaldson, Garrett & Associates, Inc. Existing base control points within IHDIV-NSWC were used as reference points. The horizontal locations of all sampling locations were surveyed to ±0.5 foot. Vertical elevations were referenced to the North American Geodetic Vertical Datum (NGVD) 1929, and horizontal positioning was referenced to 1983 North America Datum (NAD) and the Maryland State Plane Coordinate System. The top of riser pipe and ground surface elevations were surveyed to ±0.01 foot for the monitoring well locations. At the temporary well and CPT locations, only the ground surface was surveyed.

1.3.10.6 Geotechnical Soil Sampling

Fifteen subsurface soil samples were collected using split-spoon samplers and submitted for geotechnical analysis that included Unified Soil Classification System (USCS) and American Association of State Highway and Transportation Officials (AASHTO) classification, particle size distribution, specific gravity, porosity, and moisture content. Table 1-15 provides a summary of the geotechnical soil sampling results.

TABLE 1-1

MONITORING WELL GROUNDWATER LEVEL SUMMARY
SITE 57 - FORMER DRUM LOADING AREA
IHDIV-NSWC, INDIAN HEAD, MARYLAND

Well Identification	Depth to Water (feet btoc)	Top of Casing Elevation	Water-Level Elevation (feet msl)	Date
S57MW001	7.52	37.09	29.57	08/29/01
S57MW002	8.17	37.58	29.41	08/29/01
S57MW003	8.97	35.82	26.85	08/29/01
S57MW004	9.18	35.72	26.54	08/29/01
S57MW005	5.96	18.54	12.58	08/29/01
S57MW006	6.03	18.57	12.54	08/29/01
S57MW007	9.27	30.58	21.31	08/29/01
S57MW008	8.55	30.26	21.71	08/29/01
S57MW009	8.93	25.75	16.82	08/29/01
S57MW010	8.93	25.82	16.89	08/29/01
S57MW011	9.31	33.49	24.18	08/29/01
S57MW012	6.03	43.82	37.79	08/29/01
S57MW013	5.88	43.98	38.10	08/29/01
S57TW014	7.38	44.54	37.16	08/29/01
S57TW015	8.99	45.92	36.93	08/29/01
S57TW016	7.92	35.68	27.76	08/29/01
S57TW017	8.13	35.48	27.35	08/29/01
S57TW018	10.55	31.16	20.61	08/29/01
S57TW019	10.57	31.64	21.07	08/29/01
S57MW020	6.52	13.31	6.79	08/29/01
S57TW021	6.81	10.49	3.68	08/29/01
S57MW022	8.24	10.09	1.85	08/29/01
S57MW023	14.6	40.54	25.94	08/29/01
41GW01	7.77	14.97	7.20	10/08/98
41GW02	5.82	9.33	3.51	10/08/98
41GW03	4.61	11.18	6.57	10/22/97
41MW04	5.18	8.20	3.02	10/09/98

btoc - Below top of casing.
msl - Mean sea level.

TABLE 1-2

SLUG TEST HYDRAULIC CONDUCTIVITY RESULTS - 2001
SITE 57 - FORMER DRUM LOADING AREA
IHDIV-NSWC, INDIAN HEAD, MARYLAND

Monitored Interval	Well Identification	Falling Head Test (feet/day)	Rising Head Test (feet/day)	Average (feet/day)	Average (cm/sec)
Shallow	S57MW002	na	1.10	1.10	3.9E-04
	S57MW004	na	15.20	15.20	5.4E-03
	S57MW006	na	14.90	14.90	5.3E-03
	S57MW008	na	9.33	9.33	3.3E-03
	S57MW010	na	2.95	2.95	1.0E-03
	S57MW011	na	0.50	0.50	1.7E-04
	S57MW013	na	2.37	2.37	8.4E-04
	S57TW016	0.53	na	0.53	1.9E-04
	S57TW018	0.17	na	0.17	6.0E-05
	S57MW020	3.2	1.30	2.25	7.9E-04
	S57TW021	0.54	0.98	0.76	2.7E-04
	S57MW022	na	3.30	3.30	1.2E-03
	S57MW023	na	12.80	12.80	4.5E-03
		Geometric Mean =		**2.3**	**8.1E-04**
Deep	S57MW001	na	0.743	0.74	2.6E-04
	S57MW003	na	3.18	3.18	1.1E-03
	S57MW005	na	18.4	18.40	6.5E-03
	S57MW007	na	0.57	0.57	2.0E-04
	S57MW009	na	1.5	1.50	5.3E-04
	S57MW012	na	17.94	17.94	6.3E-03
	S57TW015	na	0.4	0.40	1.4E-04
	S57TW017	3.6	5.2	4.40	1.6E-03
	S57TW019	1.22	2.1	1.66	5.9E-04
		Geometric Mean =		**2.3**	**8.2E-04**
Site 57 Geometric Mean =				**2.3**	**8.2E-04**

Note:
na - Test not conducted.

TABLE 1-3

CHEMICALS RETAINED AS COPCs - UPGRADIENT AREA
SITE 57 - FORMER DRUM LOADING AREA
IHDIV-NSWC, INDIAN HEAD, MARYLAND

Chemical	Surface Soil	Subsurface Soil	Shallow Groundwater	Deep Groundwater	Surface Water	Sediment	Soil to Air	Soil to Groundwater
Volatile Organics								
Chloroform			X					
1,2-Dichloroethane			X					
1,1-Dichloroethene			X	X				
Trichloroethene			X	X				
Metals								
Arsenic	X							

Notes:
X - Indicates chemical was retained as a chemical of concern (COPC).

TABLE 1-4

CHEMICALS RETAINED AS COPCs - DOWNGRADIENT AREA
SITE 57 - FORMER DRUM LOADING AREA
IHDIV-NSWC, INDIAN HEAD, MARYLAND

Chemical	Surface Soil	Subsurface Soil	Shallow Groundwater	Deep Groundwater	Surface Water	Sediment	Soil to Air	Soil to Groundwater
Volatile Organics								
Chloroform			X	X				
cis-1,2-dichloroethene			X	X				X
1,1-Dichloroethene			X	X				
Ethyl Ether			X	X				
Methylene Chloride								X
Tetrachloroethene			X					
Trichloroethene		X	X	X			X	X
Vinyl Chloride			X	X				
Semivolatile Organics								
Benzo(a)anthracene	X							
Benzo(a)pyrene	X	X				X		
Benzo(b)fluoranthene	X							
Dibenzo(a,h)anthracene	X							
Indeno(1,2,3-cd)pyrene	X							
Metals								
Arsenic	X	X				X		X
Iron					X			
Lead	X							
Manganese					X			

Notes:
X - Indicates chemical was retained as a chemical of concern (COPC).

TABLE 1-5

CHEMICALS RETAINED AS COPCs - SEWER
SITE 57 - FORMER DRUM LOADING AREA
IHDIV-NSWC, INDIAN HEAD, MARYLAND

Chemical	Surface Water	Sediment
Volatile Organics		
Acetone	X	
cis-1,2-dichloroethene	X	
1,1-Dichloroethene	X	
Ethyl Ether	X	
Trichloroethene	X	
Vinyl Chloride		X
Semivolatile Organics		
Benzo(a)pyrene		X
Metals		
Arsenic		X
Iron	X	
Manganese	X	
Vanadium		X

Notes:
X - Indicates chemical was retained as a chemical of concern (COPC).

TABLE 1-6

ESTIMATED CANCER RISKS AND HAZARD INDICES
REASONABLE MAXIMUM EXPOSURES - UPGRADIENT AREA
SITE 57 - FORMER DRUM LOADING AREA
IHDIV-NSWC, INDIAN HEAD, MARYLAND

Exposure Route	Full Time Employee	Construction Worker	Child Resident	Adult Resident	Lifelong Resident
INCREMENTAL CANCER RISK					
Surface Soil					
Incidental Ingestion	2.5E-06	NA	NA	NA	NA
Dermal Contact	1.3E-06	NA	NA	NA	NA
Total	3.8E-06	NA	NA	NA	NA
All Soil					
Incidental Ingestion	NA	9.7E-07	1.6E-05	6.8E-06	2.3E-05
Dermal Contact	NA	6.4E-08	8.3E-07	7.1E-07	1.5E-06
Total	NA	1.0E-06	1.7E-05	7.5E-06	2.4E-05
Groundwater					
Incidental Ingestion	NA	NA	3.0E-04	4.4E-04	7.4E-04
Dermal Contact	NA	5.8E-07	2.3E-05	5.6E-05	8.3E-05
Inhalation	NA	6.2E-08	NA	1.6E-04	1.6E-04
Total	NA	6.4E-07	3.3E-04	6.6E-04	9.8E-04
Surface Water					
Incidental Ingestion	NA	NA	NA	NA	NA
Dermal Contact	NA	NA	NA	NA	NA
Total	NA	NA	NA	NA	NA
Sediment					
Incidental Ingestion	NA	NA	NA	NA	NA
Dermal Contact	NA	NA	NA	NA	NA
Total	NA	NA	NA	NA	NA
Total All Pathways	3.8E-06	1.7E-06	3.4E-04	6.6E-04	1.0E-03
HAZARD INDEX					
Surface Soil					
Incidental Ingestion	1.6E-02	NA	NA	NA	NA
Dermal Contact	8.1E-03	NA	NA	NA	NA
Total	2.4E-02	NA	NA	NA	NA
All Soil					
Incidental Ingestion	NA	1.5E-01	3.5E-01	4.4E-02	NA
Dermal Contact	NA	1.0E-02	1.8E-02	4.6E-03	NA
Total	NA	1.6E-01	3.7E-01	4.8E-02	NA
Groundwater					
Incidental Ingestion	NA	NA	5.9E-01	2.5E-01	NA
Dermal Contact	NA	7.9E-03	5.3E-02	3.3E-02	NA
Inhalation	NA	7.2E-04	NA	5.2E-01	NA
Total	NA	8.7E-03	6.4E-01	8.0E-01	NA
Surface Water					
Incidental Ingestion	NA	NA	NA	NA	NA
Dermal Contact	NA	NA	NA	NA	NA
Total	NA	NA	NA	NA	NA
Sediment					
Incidental Ingestion	NA	NA	NA	NA	NA
Dermal Contact	NA	NA	NA	NA	NA
Total	NA	NA	NA	NA	NA
Total All Pathways	2.4E-02	1.7E-01	1.0E+00	8.5E-01	NA

Notes:
NA - Not applicable for this receptor.
NT - No toxicity criteria available.
Shading indicates unacceptable risk.

TABLE 1-7

ESTIMATED CANCER RISKS AND HAZARD INDICES
CENTRAL TENDENCY EXPOSURES - UPGRADIENT AREA
SITE 57 - FORMER DRUM LOADING AREA
IHDIV-NSWC, INDIAN HEAD, MARYLAND

Exposure Route	Full Time Employee	Construction Worker	Child Resident	Adult Resident	Lifelong Resident
INCREMENTAL CANCER RISK					
Surface Soil					
Incidental Ingestion	2.2E-07	NA	NA	NA	NA
Dermal Contact	2.3E-08	NA	NA	NA	NA
Total	2.4E-07	NA	NA	NA	NA
All Soil					
Incidental Ingestion	NA	4.2E-07	1.8E-06	6.6E-07	2.4E-06
Dermal Contact	NA	5.6E-09	5.5E-08	2.0E-08	7.5E-08
Total	NA	4.3E-07	1.8E-06	6.8E-07	2.5E-06
Groundwater					
Incidental Ingestion	NA	NA	5.7E-05	6.0E-05	1.2E-04
Dermal Contact	NA	2.9E-07	4.2E-06	9.0E-06	1.3E-05
Inhalation	NA	3.1E-08	NA	1.7E-05	1.7E-05
Total	NA	3.2E-07	6.1E-05	8.6E-05	1.5E-04
Surface Water					
Incidental Ingestion	NA	NA	NA	NA	NA
Dermal Contact	NA	NA	NA	NA	NA
Total	NA	NA	NA	NA	NA
Sediment					
Incidental Ingestion	NA	NA	NA	NA	NA
Dermal Contact	NA	NA	NA	NA	NA
Total	NA	NA	NA	NA	NA
Total All Pathways	2.4E-07	7.5E-07	6.3E-05	8.7E-05	1.5E-04

Exposure Route	Full Time Employee	Construction Worker	Child Resident	Adult Resident	Lifelong Resident
HAZARD INDEX					
Surface Soil					
Incidental Ingestion	6.9E-03	NA	NA	NA	NA
Dermal Contact	7.1E-04	NA	NA	NA	NA
Total	7.6E-03	NA	NA	NA	NA
All Soil					
Incidental Ingestion	NA	6.6E-02	1.4E-01	1.5E-02	NA
Dermal Contact	NA	8.7E-04	4.3E-03	4.4E-04	NA
Total	NA	6.7E-02	1.4E-01	1.5E-02	NA
Groundwater					
Incidental Ingestion	NA	NA	3.9E-01	1.2E-01	NA
Dermal Contact	NA	4.0E-03	2.9E-02	1.8E-02	NA
Inhalation	NA	7.2E-04	NA	1.9E-01	NA
Total	NA	4.7E-03	4.2E-01	3.3E-01	NA
Surface Water					
Incidental Ingestion	NA	NA	NA	NA	NA
Dermal Contact	NA	NA	NA	NA	NA
Total	NA	NA	NA	NA	NA
Sediment					
Incidental Ingestion	NA	NA	NA	NA	NA
Dermal Contact	NA	NA	NA	NA	NA
Total	NA	NA	NA	NA	NA
Total All Pathways	7.6E-03	7.1E-02	5.6E-01	3.4E-01	NA

Notes:
NA - Not applicable for this receptor.
NT - No toxicity criteria available.
Shading indicates unacceptable risk.

TABLE 1-8

ESTIMATED CANCER RISKS AND HAZARD INDICES
REASONABLE MAXIMUM EXPOSURES - DOWNGRADIENT AREA
SITE 57 - FORMER DRUM LOADING AREA
IHDIV-NSWC, INDIAN HEAD, MARYLAND

Exposure Route	Full Time Employee	Construction Worker	Child Resident	Adult Resident	Lifelong Resident
INCREMENTAL CANCER RISK					
Surface Soil					
Incidental Ingestion	3.1E-05	NA	NA	NA	NA
Dermal Contact	2.2E-05	NA	NA	NA	NA
Total	5.2E-05	NA	NA	NA	NA
All Soil					
Incidental Ingestion	NA	8.2E-06	1.4E-04	5.7E-05	1.9E-04
Dermal Contact	NA	7.5E-07	1.0E-05	1.3E-04	9.1E-05
Inhalation	NA	6.4E-09	4.3E-08	3.3E-08	7.7E-08
Total	NA	8.9E-06	1.5E-04	1.4E-04	2.8E-04
Groundwater					
Incidental Ingestion	NA	NA	1.2E-03	1.7E-03	2.9E-03
Dermal Contact	NA	1.2E-06	4.2E-05	1.0E-04	1.5E-04
Inhalation	NA	1.5E-07	NA	4.4E-04	4.4E-04
Total	NA	1.4E-06	1.2E-03	2.3E-03	3.5E-03
Surface Water					
Incidental Ingestion	NA	NT	NT	NT	NT
Dermal Contact	NA	NT	NT	NT	NT
Total	NA	NT	NT	NT	NT
Sediment					
Incidental Ingestion	NA	6.4E-08	4.0E-07	1.7E-07	5.7E-07
Dermal Contact	NA	9.4E-09	2.8E-08	5.3E-07	5.6E-07
Total	NA	7.3E-08	4.3E-07	7.1E-07	1.2E-06
Total All Pathways	5.2E-05	1.0E-05	1.4E-03	2.4E-03	3.8E-03
HAZARD INDEX					
Surface Soil					
Incidental Ingestion	1.7E-01	NA	NA	NA	NA
Dermal Contact	8.7E-02	NA	NA	NA	NA
Total	2.5E-01	NA	NA	NA	NA
All Soil					
Incidental Ingestion	NA	1.1E+00	3.1E+00	6.6E-01	NA
Dermal Contact	NA	6.3E-03	1.6E-01	6.9E-02	NA
Inhalation	NA	NT	NT	NT	NA
Total	NA	1.1E+00	3.2E+00	7.2E-01	NA
Groundwater					
Incidental Ingestion	NA	NA	1.1E+01	4.9E+00	NA
Dermal Contact	NA	1.3E-01	9.9E-01	6.1E-01	NA
Inhalation	NA	1.3E-03	NA	3.6E-06	NA
Total	NA	1.3E-01	1.2E+01	5.5E+00	NA
Surface Water					
Incidental Ingestion	NA	3.9E-03	1.2E-02	2.6E-03	NA
Dermal Contact	NA	2.5E-02	1.2E-02	3.8E-03	NA
Total	NA	2.9E-02	2.4E-02	6.4E-03	NA
Sediment					
Incidental Ingestion	NA	8.8E-03	9.2E-03	9.8E-04	NA
Dermal Contact	NA	9.5E-04	4.8E-04	2.3E-03	NA
Total	NA	9.8E-03	9.6E-03	3.2E-03	NA
Total All Pathways	2.5E-01	1.3E+00	1.6E+01	6.7E+00	NA

Notes:
NA - Not applicable for this receptor.
NT - No toxicity criteria available.
Shading indicates unacceptable risk.

TABLE 1-9

ESTIMATED CANCER RISKS AND HAZARD INDICES
CENTRAL TENDENCY EXPOSURES - DOWNGRADIENT AREA
SITE 57 - FORMER DRUM LOADING AREA
IHDIV-NSWC, INDIAN HEAD, MARYLAND

Exposure Route	Full Time Employee	Construction Worker	Child Resident	Adult Resident	Lifelong Resident
INCREMENTAL CANCER RISK					
Surface Soil					
Incidental Ingestion	2.7E-06	NA	NA	NA	NA
Dermal Contact	3.8E-07	NA	NA	NA	NA
Total	3.1E-06	NA	NA	NA	NA
All Soil					
Incidental Ingestion	NA	3.6E-06	1.5E-05	5.6E-06	2.1E-05
Dermal Contact	NA	6.6E-08	6.7E-07	6.2E-06	6.9E-06
Inhalation	NA	1.7E-08	1.8E-08	1.2E-08	3.0E-08
Total	NA	3.7E-06	1.6E-05	1.2E-05	2.8E-05
Groundwater					
Incidental Ingestion	NA	NA	2.3E-04	2.4E-04	4.7E-04
Dermal Contact	NA	6.1E-07	7.6E-06	1.6E-05	2.4E-05
Inhalation	NA	7.7E-08	NA	4.7E-05	4.7E-05
Total	NA	6.8E-07	2.3E-04	3.0E-04	5.4E-04
Surface Water					
Incidental Ingestion	NA	NT	NT	NT	NT
Dermal Contact	NA	NT	NT	NT	NT
Total	NA	NT	NT	NT	NT
Sediment					
Incidental Ingestion	NA	1.6E-08	3.3E-08	1.2E-08	4.5E-08
Dermal Contact	NA	4.7E-10	1.4E-09	1.5E-08	1.6E-08
Total	NA	1.6E-08	3.5E-08	2.7E-08	6.2E-08
Total All Pathways	3.1E-06	4.4E-06	2.5E-04	3.1E-04	5.6E-04
HAZARD INDEX					
Surface Soil					
Incidental Ingestion	7.4E-02	NA	NA	NA	NA
Dermal Contact	7.6E-03	NA	NA	NA	NA
Total	8.1E-02	NA	NA	NA	NA
All Soil					
Incidental Ingestion	NA	4.9E-01	1.0E+00	2.2E-01	NA
Dermal Contact	NA	6.3E-03	3.2E-02	6.6E-03	NA
Inhalation	NA	NT	NT	NT	NA
Total	NA	5.0E-01	1.1E+00	2.3E-01	NA
Groundwater					
Incidental Ingestion	NA	NA	7.6E+00	2.3E+00	NA
Dermal Contact	NA	6.4E-02	5.4E-01	3.3E-01	NA
Inhalation	NA	6.7E-04	NA	4.7E-05	NA
Total	NA	6.5E-02	8.2E+00	2.6E+00	NA
Surface Water					
Incidental Ingestion	NA	2.0E-03	3.0E-03	6.5E-04	NA
Dermal Contact	NA	1.2E-02	1.6E-03	9.6E-04	NA
Total	NA	1.4E-02	4.6E-03	1.6E-03	NA
Sediment					
Incidental Ingestion	NA	2.2E-03	2.3E-03	2.5E-04	NA
Dermal Contact	NA	4.7E-05	7.2E-05	2.2E-04	NA
Total	NA	2.3E-03	2.4E-03	4.6E-04	NA
Total All Pathways	8.1E-02	5.8E-01	9.2E+00	2.8E+00	NA

Notes:
NA - Not applicable for this receptor.
NT - No toxicity criteria available.
Shading indicates unacceptable risk.

TABLE 1-10

**ESTIMATED CANCER RISKS AND HAZARD INDICES
SEWERS
SITE 57 - FORMER DRUM LOADING AREA
IHDIV-NSWC, INDIAN HEAD, MARYLAND**

Exposure Route	Construction Workers	
	RME	CTE
INCREMENTAL CANCER RISK		
Surface Water		
Incidental Ingestion	7.7E-10	7.5E-09
Dermal Contact	5.8E-09	2.9E-09
Total	6.6E-09	1.0E-08
Sediment		
Incidental Ingestion	1.3E-07	3.4E-08
Dermal Contact	2.1E-08	1.0E-09
Total	1.6E-07	3.5E-08
Total All Pathways	1.6E-07	4.5E-08
HAZARD INDEX		
Surface Water		
Incidental Ingestion	4.2E-03	6.7E-02
Dermal Contact	1.4E-02	6.9E-03
Total	1.8E-02	7.4E-02
Sediment		
Incidental Ingestion	2.5E-02	6.3E-03
Dermal Contact	7.4E-03	3.7E-04
Total	3.3E-02	6.7E-03
Total All Pathways	5.1E-02	8.0E-02

TABLE 1-11
PRE-FS ENVIRONMENTAL SAMPLING AND ANALYSIS SUMMARY - SOIL SAMPLES
SITE 57 – FORMER DRUM LOADING AREA
IHDIV-NSWC, INDIAN HEAD, MARYLAND

Location	Sample Designation	Sample Depth (feet bgs[1])	Chemical Laboratory					Geotechnical Laboratory		
			Arsenic	TOC[2]	TCL VOCs[3] (with ethyl ether)	Cation Exchange Capacity	pH	Grain Size Analysis	Soil Classification	Bulk Density
Surface Soil										
S57SS016	S57SS0160103	0 – 0.5	•		•					
S57SS017	S57SS0170103	0 – 0.5	•		•					
S57SS018	S57SS0180103	0 – 0.5	•		•					
S57SS019	S57SS0190103	0 – 0.5			•					
S57SS020	S57SS0200103	0 – 0.5	•							
S57SS021	S57SS0210103	0 – 0.5	•		•					
S57SS022	S57SS0220103	0 – 0.5	•		•					
S57SS023	S57SS0230103	0 – 0.5			•					
S57SS024	S57SS0240103	0 – 0.5			•					
S57SS025	S57SS0250103	0 – 0.5			•					
S57SS027/ MW015	S57SS0270103	0 – 0.5			•					
S57SS028/ MW017	S57SS0280103	0 – 0.5			•					
S57SS029/ MW019	S57SS0290103	0 – 0.5			•					
Subsurface Soil										
S57SB016	S57SB0160103	4 – 5	•		•	•	•	•	•	•
	S57SB0160203	8 – 10			•					
	S57SB0160303	18 – 20			•	•	•	•	•	•
S57SB017	S57SB0170103	4 – 5	•		•					
	S57SB0170203	8 – 10			•					
	S57SB0170303	14 – 16			•					
	S57SB0170303	18 – 20			•					
S57SB018	S57SB0180103	4 – 5	•		•	•	•	•	•	•
	S57SB0180203	8 – 10			•					
	S57SB0180303	16 – 18			•	•	•	•	•	•
	S57SB0180403	18 – 20			•					

TABLE 1-11
PRE-FS ENVIRONMENTAL SAMPLING AND ANALYSIS SUMMARY - SOIL SAMPLES
SITE 57 – FORMER DRUM LOADING AREA
IHDIV-NSWC, INDIAN HEAD, MARYLAND

Location	Sample Designation	Sample Depth (feet bgs[1])	Chemical Laboratory					Geotechnical Laboratory		
			Arsenic	TOC[2]	TCL VOCs[3] (with ethyl ether)	Cation Exchange Capacity	pH	Grain Size Analysis	Soil Classification	Bulk Density
S57SB019	S57SB0190103	4 – 5			•					
	S57SB0190203	8 – 10			•					
	S57SB0190303	14 – 16			•					
	S57SB0190403	18 – 20			•					
S57SB020	S57SB0200103	4 – 5	•							
S57SB021	S57SB0210103	4 – 5			•			•	•	•
	S57SB0210203	8 – 10			•					
	S57SB0210303	14 – 16		•	•	•	•	•	•	•
	S57SB0210403	18 – 20			•					
S57SB022	S57SB0220103	4 – 5		•	•	•	•	•	•	•
	S57SB0220203	8 – 10			•					
	S57SB0220303	12 – 14		•	•	•	•	•	•	•
	S57SB0220403	18 – 20			•					
S57SB023	S57SB0230103	4 – 5			•					
	S57SB0230203	8 – 10			•					
	S57SB0230303	12 – 14			•					
S57SB024	S57SB0240103	4 – 5		•	•	•	•	•	•	•
	S57SB0240203	8 – 10			•					
S57SB025	S57SB0250103	4 – 5			•					
	S57SB0250203	8 – 10			•					
	S57SB0250203	12 – 14			•					
S57SB026	S57SB0260103	8 – 9		•						
S57SB027/ MW015	S57SB0270103	4 – 5			•					
	S57SB0270203	8 – 10			•					
	S57SB0270303	12 – 14			•					
	S57SB0270403	16 – 18			•					

TABLE 1-11
PRE-FS ENVIRONMENTAL SAMPLING AND ANALYSIS SUMMARY - SOIL SAMPLES
SITE 57 – FORMER DRUM LOADING AREA
IHDIV-NSWC, INDIAN HEAD, MARYLAND

Location	Sample Designation	Sample Depth (feet bgs[1])	Chemical Laboratory					Geotechnical Laboratory		
			Arsenic	TOC[2]	TCL VOCs[3] (with ethyl ether)	Cation Exchange Capacity	pH	Grain Size Analysis	Soil Classification	Bulk Density
S57SB028/ MW017	S57SB0280103	4 – 5			•					
	S57SB0280203	10 – 12			•					
	S57SB0280303	12 – 14			•					
	S57SB0280403	18 – 20			•					
S57SB029/ MW019	S57SB0290103	4 – 5			•					
	S57SB0290203	10 – 12			•					
	S57SB0290303	20 – 22			•					
	S57SB0290403	24 – 26			•					
S57SB030	S57SB0300103	4 – 6			•					
	S57SB0300203	8 – 10		•	•		•	•	•	•
	S57SB0300303	14 – 16			•					
	S57SB0300403	22 – 24		•	•		•	•	•	•
S57SB031	S57SB0310103	4 – 6			•					
	S57SB0310203	8 – 10		•	•		•	•	•	•
	S57SB0310303	14 – 16			•					
	S57SB0310403	18 – 20		•	•		•	•	•	•
S57SB032	S57SB0320103	6 – 8			•					
	S57SB0320203	8 – 10		•	•		•	•	•	•
	S57SB0320303	14 – 16			•					
	S57SB0320403	18 – 20		•	•		•	•	•	•
S57SB033	S57SB0330103	10 – 12			•					

(1) bgs Below ground surface.
(2) TOC Total organic carbon.
(3) TCL VOCs Target Compound List volatile organic compounds.

TABLE 1-12

SUMMARY OF POSITIVE DETECTIONS - SOIL
SITE 57 - FORMER DRUM LOADING AREA
IHDIV-NSWC, INDIAN, HEAD, MARYLAND

Analyte	S57SB016 0 - 0.5	S57SB016 4 - 5	S57SB016-D 4 - 5	S57SB016 8 - 10	S57SB016 18 - 20	S57SB017 0 - 0.5	S57SB017-D 0 - 0.5	S57SB017 4 - 5	S57SB017 8 - 10
Volatile Organics (µg/kg)									
Acetone				280					
2-Butanone									
cis-1,2-Dichloroethene						21	24	16	
Diethyl ether					8.3				
Ethylbenzene									
2-Hexanone									
Methlyene chloride									
4-Methyl-2-pentanone									
m+p Xylenes									
o-Xylene									
Toluene									
trans-1,2-Dichloroethene									
Trichloroethene			5.6			220	210	5.5	
Metals (mg/kg)									
Arsenic	6.9	35.2		NA	NA	21	21.8	2.6	NA

Notes:
Blank - Not detected.
NA - Not analyzed.

TABLE 1-12

SUMMARY OF POSITIVE DETECTIONS - SOIL
SITE 57 - FORMER DRUM LOADING AREA
IHDIV-NSWC, INDIAN, HEAD, MARYLAND

Analyte	S57SB017 14 - 16	S57SB017 18 - 20	S57SB018 0 - 0.5	S57SB018-D 0 - 0.5	S57SB018 4 - 5	S57SB018 8 - 10	S57SB018 16 - 18	S57SB018 18 - 20	S57SB019 0 - 0.5	S57SB019 4 - 5
Volatile Organics (µg/kg)										
Acetone										
2-Butanone										
cis-1,2-Dichloroethene					84				12	32
Diethyl ether							36	4.6		
Ethylbenzene										
2-Hexanone										
Methlyene chloride										
4-Methyl-2-pentanone										
m+p Xylenes										
o-Xylene										
Toluene										
trans-1,2-Dichloroethene										
Trichloroethene					270				49	52
Metals (mg/kg)										
Arsenic	NA	NA	26.6	22.6	2.3	NA	NA	NA	NA	NA

Notes:
Blank - Not detected.
NA - Not analyzed.

TABLE 1-12

SUMMARY OF POSITIVE DETECTIONS - SOIL
SITE 57 - FORMER DRUM LOADING AREA
IHDIV-NSWC, INDIAN, HEAD, MARYLAND

Analyte	S57SB019 8 - 10	S57SB019 14 - 16	S57SB019 18 - 20	S57SB020 0 - 0.5	S57SB020 4 - 5	S57SB021 0 - 0.5	S57SB021 4 - 5	S57SB021 8 - 10	S57SB021-D 8 - 10	S57SB021 14 - 16
Volatile Organics (µg/kg)										
Acetone		2400		NA	NA					
2-Butanone				NA	NA		25			
cis-1,2-Dichloroethene		22		NA	NA	16	16	690	240	
Diethyl ether		10		NA	NA					
Ethylbenzene										
2-Hexanone				NA	NA		23			
Methlyene chloride										
4-Methyl-2-pentanone				NA	NA		16			
m+p Xylenes				NA	NA		3.1			
o-Xylene										
Toluene				NA	NA		3.2			
trans-1,2-Dichloroethene				NA	NA			5.9		
Trichloroethene	4.6	45		NA	NA	53	82	98	41	
Metals (mg/kg)										
Arsenic	NA	NA	NA	33.6	3.3	79.9	NA	NA	NA	NA

Notes:
Blank - Not detected.
NA - Not analyzed.

TABLE 1-12

SUMMARY OF POSITIVE DETECTIONS - SOIL
SITE 57 - FORMER DRUM LOADING AREA
IHDIV-NSWC, INDIAN, HEAD, MARYLAND

Analyte	S57SB021 18 - 20	S57SB022 0 - 0.5	S57SB022 4 - 5	S57SB022 8 - 10	S57SB022 12 - 14	S57SB022 18 - 20	S57SB023 0 - 0.5	S57SB023 4 - 5	S57SB023 8 - 10	S57SB023 12 - 14
Volatile Organics (µg/kg)										
Acetone										
2-Butanone										
cis-1,2-Dichloroethene		14	15				3.9			
Diethyl ether						13				
Ethylbenzene										
2-Hexanone										
Methlyene chloride										
4-Methyl-2-pentanone										
m+p Xylenes										
o-Xylene										
Toluene									3.7	
trans-1,2-Dichloroethene										
Trichloroethene		21	7.5	43			20			
Metals (mg/kg)										
Arsenic	NA	2.7	NA	NA	NA	NA	NA	NA	NA	NA

Notes:
Blank - Not detected.
NA - Not analyzed.

TABLE 1-12

SUMMARY OF POSITIVE DETECTIONS - SOIL
SITE 57 - FORMER DRUM LOADING AREA
IHDIV-NSWC, INDIAN, HEAD, MARYLAND
PAGE 5 OF 8

Analyte	S57SB024 0 - 0.5	S57SB024 4 - 5	S57SB024 8 - 10	S57SB025 0 - 0.5	S57SB025 4 - 5	S57SB025 8 - 10	S57SB025 12 - 14	S57SB027 0 - 0.5	S57SB027 4 - 5	S57SB027 8 - 10
Volatile Organics (μg/kg)										
Acetone										
2-Butanone										
cis-1,2-Dichloroethene						11	4.7			
Diethyl ether							18			2100
Ethylbenzene				9.6						
2-Hexanone										
Methlyene chloride										
4-Methyl-2-pentanone										
m+p Xylenes	2.8			35			2.6			
o-Xylene	3									
Toluene				5.2						
trans-1,2-Dichloroethene										
Trichloroethene				8						
Metals (mg/kg)										
Arsenic	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes:
Blank - Not detected.
NA - Not analyzed.

TABLE 1-12

SUMMARY OF POSITIVE DETECTIONS - SOIL
SITE 57 - FORMER DRUM LOADING AREA
IHDIV-NSWC, INDIAN, HEAD, MARYLAND

Analyte	S57SB027 12 - 14	S57SB027 16 - 18	S57SB028 0 - 0/5	S57SB028 4 - 5	S57SB028-D 4 - 5	S57SB028 10 - 12	S57SB028 12 - 24	S57SB028 18 - 20	S57SB029 0 - 0.5	S57SB029 4 - 5
Volatile Organics (µg/kg)										
Acetone										
2-Butanone										11
cis-1,2-Dichloroethene										
Diethyl ether	750	230				11	54	14		
Ethylbenzene										
2-Hexanone										
Methlyene chloride										
4-Methyl-2-pentanone										
m+p Xylenes										
o-Xylene										
Toluene										
trans-1,2-Dichloroethene										
Trichloroethene										
Metals (mg/kg)										
Arsenic	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes:
Blank - Not detected.
NA - Not analyzed.

TABLE 1-12

SUMMARY OF POSITIVE DETECTIONS - SOIL
SITE 57 - FORMER DRUM LOADING AREA
IHDIV-NSWC, INDIAN, HEAD, MARYLAND
PAGE 7 OF 8

Analyte	S57SB029 10 - 12	S57SB029 20 - 22	S57SB029 24 - 26	S57SB029-D 24 - 26	S57SB030 4 - 6	S57SB030 8 - 10	S57SB030-D 8 - 10	S57SB030 14 - 16	S57SB030 22 - 24
Volatile Organics (µg/kg)									
Acetone									
2-Butanone									
cis-1,2-Dichloroethene									
Diethyl ether									
Ethylbenzene									
2-Hexanone									
Methlyene chloride									
4-Methyl-2-pentanone									
m+p Xylenes									
o-Xylene									
Toluene									
trans-1,2-Dichloroethene									
Trichloroethene									
Metals (mg/kg)									
Arsenic	NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes:
Blank - Not detected.
NA - Not analyzed.

TABLE 1-12

SUMMARY OF POSITIVE DETECTIONS - SOIL
SITE 57 - FORMER DRUM LOADING AREA
IHDIV-NSWC, INDIAN, HEAD, MARYLAND

Analyte	S57SB031 4 - 6	S57SB031 8 - 10	S57SB031-D 8 - 10	S57SB031 14 - 16	S57SB031 18 - 20	S57SB032 6 - 8	S57SB032 8 - 10	S57SB032 14 - 16	S57SB032 18 - 20	S57SB033 10 - 12
Volatile Organics (µg/kg)										
Acetone										
2-Butanone										
cis-1,2-Dichloroethene										
Diethyl ether										
Ethylbenzene										
2-Hexanone										
Methlyene chloride										1.3
4-Methyl-2-pentanone										
m+p Xylenes										
o-Xylene										
Toluene										
trans-1,2-Dichloroethene										
Trichloroethene										
Metals (mg/kg)										
Arsenic	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes:
Blank - Not detected.
NA - Not analyzed.

TABLE 1-13

MONITORING WELL CONSTRUCTION SUMMARY
SITE 57 - FORMER DRUM LOADING AREA
IHDIV-NSWC, INDIAN HEAD, MARYLAND

Well Number	Northing	Easting	Ground Elevation (ft msl)	Top of Riser Elevation (ft msl)	Total Depth (ft bgs)	Screen Interval (ft bgs)	Screen Length (ft)	Top of Screen Elevation (ft msl)	Bottom of Screen Elevation (ft msl)	Total Depth (below top of riser)	Monitored Hydrogeologic Unit	Completion Type	Date Installed	Abandonment Date
	NAD 1983 Datum													
S57MW001	335,394.46	1,263,650.94	35.57	37.09	26	14 - 24	10	21.57	11.57	26.25	deep surficial	stick-up	1/6/1999	NA
S57MW002	335,397.69	1,263,649.26	35.72	37.58	13.5	3 - 13	10	32.72	22.72	14.32	shallow surficial	stick-up	1/6/1999	NA
S57MW003	335,285.64	1,263,748.26	33.83	35.82	22.5	17 - 22	5	16.83	11.83	24.35	deep surficial	stick-up	1/22/1999	NA
S57MW004	335,289.36	1,263,746.88	33.91	35.72	16.5	6 - 16	10	27.91	17.91	16.15	shallow surficial	stick-up	1/7/1999	NA
S57MW005	334,578.38	1,264,177.60	16.18	18.54	20	13 - 18	5	3.18	-1.82	19.8	deep surficial	stick-up	1/11/1999	NA
S57MW006	334,576.70	1,264,181.97	16.57	18.57	12.5	2 - 12	10	14.57	4.57	14.2	shallow surficial	stick-up	1/11/1999	NA
S57MW007	335,082.26	1,263,768.13	28.17	30.58	30	16 - 26	10	12.17	2.17	28.6	deep surficial	stick-up	1/10/1999	NA
S57MW008	335,084.77	1,263,765.00	28.09	30.26	15.5	5 - 15	10	23.09	13.09	15.5	shallow surficial	stick-up	1/10/1999	NA
S57MW009	334,897.38	1,263,862.13	23.9	25.75	20	14 - 19	5	9.9	4.9	20	deep surficial	stick-up	1/12/1999	NA
S57MW010	334,894.06	1,263,861.24	23.34	25.82	14.5	4 - 14	10	19.34	9.34	16	shallow surficial	stick-up	1/11/1999	NA
S57MW011	335,222.16	1,263,751.17	31.61	33.49	20	9 - 19	10	22.61	12.61	19.69	shallow surficial	stick-up	1/7/1999	NA
S57MW012	335,575.45	1,263,497.42	41.74	43.82	43.5	33 - 43	10	8.74	-1.26	44.3	deep surficial	stick-up	1/9/1999	NA
S57MW013	335,577.33	1,263,500.08	41.9	43.98	16.5	6 - 16	10	35.9	25.9	17.95	shallow surficial	stick-up	1/12/1999	NA
S57TW001	334,862.81	1,263,841.35	22.77	24.78	12	2 - 12	10	20.77	10.77	14.01	shallow surficial	temporary	1/19/1999	1/28/1999
S57TW002	334,440.19	1,264,429.70	10.09	11.94	12	3 - 8	5	7.09	2.09	9.85	shallow surficial	temporary	1/19/1999	1/28/1999
S57TW003	334,055.20	1,264,862.80	6.63	7.12	12	4.5 - 9.5	5	2.13	-2.87	9.99	shallow surficial	temporary	1/19/1999	1/28/1999
S57TW014	335,445.15	1,263,459.21	42.51	44.54	10	4 - 9	5	38.51	33.51	11.7	shallow surficial	temporary	8/22/2001	10/24/2001
S57TW015	335,449.71	1,263,455.01	42.71	45.92	30	25 - 30	5	17.71	12.71	32.9	deep surficial	temporary	8/24/2001	10/24/2001
S57TW016	335,291.18	1,263,603.59	34.83	35.68	10	5 - 10	5	29.83	24.83	11.92	shallow surficial	temporary	8/17/2001	10/24/2001
S57TW017	335,289.40	1,263,606.71	34.78	35.48	24	13 - 23	10	21.78	11.78	25	deep surficial	temporary	8/16/2001	10/24/2001

NA - Not abandoned.
na - Not applicable.
msl - Mean sea level.
bgs - Below ground surface.
All elevations are referenced to NGVD 29.
(1) - Below the lower surficial aquitard.

TABLE 1-13

MONITORING WELL CONSTRUCTION SUMMARY
SITE 57 - FORMER DRUM LOADING AREA
IHDIV-NSWC, INDIAN HEAD, MARYLAND

Well Number	Northing	Easting	Ground Elevation (ft msl)	Top of Riser Elevation (ft msl)	Total Depth (ft bgs)	Screen Interval (ft bgs)	Screen Length (ft)	Top of Screen Elevation (ft msl)	Bottom of Screen Elevation (ft msl)	Total Depth (below top of riser)	Monitored Hydrogeologic Unit	Completion Type	Date Installed	Abandonment Date
	NAD 1983 Datum													
S57TW018	335,080.92	1,263,895.89	30.71	31.16	15	9.5 - 14.5	5	21.21	16.21	15	shallow surficial	temporary	8/20/2001	10/24/2001
S57TW019	335,078.62	1,263,897.69	30.64	31.64	24	19 - 24	5	11.64	6.64	25	deep surficial	temporary	8/17/2001	10/24/2001
S57MW020	334,440.46	1,264,429.15	10.39	13.31	14	4 - 14	10	6.39	-3.61	17.58	shallow surficial	stick-up	8/22/2001	NA
S57TW021	334,173.08	1,264,593.47	9.84	10.49	25	9 - 14	5	0.84	-4.16	14.65	shallow surficial	temporary	8/21/2001	10/24/2001
S57MW022	334,065.57	1,264,908.66	8.11	10.09	14	4 - 14	10	4.11	-5.89	17.45	shallow surficial	stick-up	8/22/2001	NA
S57MW023	334,392.01	1,263,440.68	37.44	40.54	20	10 - 20	10	27.44	17.44	23.1	shallow surficial	stick-up	8/22/2001	NA
41GW01	334,130.33	1,263,811.38	12.69	14.97	18.5	8.5 - 18.5	10	4.19	-5.81	20.3	shallow surficial	stick-up	9/1/1992	NA
41GW02	333,984.15	1,264,245.77	6.87	9.33	18.5	8.5 - 18.5	10	-1.63	-11.63	20.22	shallow surficial	stick-up	9/1/1992	NA
41GW03	334,124.36	1,264,054.95	8.54	11.18	18.5	8.5 - 18.5	10	0.04	-9.96	20.1	shallow surficial	stick-up	9/2/1992	98
41MW04	334,035.83	1,264,056.62	8.47	8.20	15.5	5 - 15	10	3.47	-6.53	14.73	shallow surficial	flush	10/8/1998	NA
S57CP001	335,041.75	1,263,378.61	75.96	na	43.2	14 - 16	2	61.96	59.96	na	(1)	temporary	8/30/2001	8/30/2001
S57CP002	334,733.23	1,263,591.09	39	na	53.3	na - na	na	na	na	na	(1)	temporary	8/30/2001	8/30/2001
S57CP003	334,820.26	1,264,059.09	34.42	na	52.7	43 - 45	2	-8.58	-10.58	na	(1)	temporary	8/30/2001	8/30/2001
S57CP004	334,365.84	1,264,190.00	20.41	na	23	21 - 23	2	-0.59	-2.59	na	(1)	temporary	8/28/2001	8/28/2001
S57CP005	334,071.68	1,264,896.71	8.25	na	20.5	17 - 19	2	-8.75	-10.75	na	(1)	temporary	8/29/2001	8/29/2001
S57CP006	333,968.89	1,264,640.78	6.78	na	31.5	25 - 27	2	-18.22	-20.22	na	(1)	temporary	8/29/2001	8/29/2001
S57CP007	334,278.06	1,264,026.24	29.14	na	43	na - na	na	na	na	na	(1)	temporary	8/30/2001	8/30/2001
S57CP008	334,208.41	1,263,509.08	28.52	na	32.7	27 - 29	2	1.52	-0.48	na	(1)	temporary	8/29/2001	8/29/2001
S57CP009	334,378.55	1,263,452.66	38.35	na	55.3	na - na	na	na	na	na	(1)	temporary	8/29/2001	8/29/2001
S57CP010	335,292.06	1,263,606.29	34.98	na	49.2	37.5 - 39.5	2	-2.52	-4.52	na	(1)	temporary	8/28/2001	8/28/2001

NA - Not abandoned.
na - Not applicable.
msl - Mean sea level.
bgs - Below ground surface.
All elevations are referenced to NGVD 29.
(1) - Below the lower surficial aquitard.

TABLE 1-14

SUMMARY OF POSITIVE DETECTIONS - GROUNDWATER
SITE 57 - FORMER DRUM LOADING AREA
IHDIV-NSWC, INDIAN HEAD, MARYLAND

Analyte	S57CP004	S57CP005	S57CP005-D	S57CP006	S57CP010	S57MW001	S57MW002	S57MW003	S57MW003-D
Acetone									
Benzene									
cis-1,2-Dichloroethene							2.6	47	14
1,1-Dichloroethane									
1,2-Dichloroethane									
1,1-Dichloroethene									
Diethyl ether		800				450	930	440	320
Methlyene chloride									
o-Xylene									
Tetrachloroethene									
trans-1,2-Dichloroethene									
1,1,1-Trichloroethane									
Trichloroethene		11	9.4			2.6	43	450	280
Vinyl chloride									

Notes:
Blank - Not detected.

TABLE 1-14

SUMMARY OF POSITIVE DETECTIONS - GROUNDWATER
SITE 57 - FORMER DRUM LOADING AREA
IHDIV-NSWC, INDIAN HEAD, MARYLAND

Analyte	S57MW004	S57MW005	S57MW006	S57MW007	S57MW007-D	S57MW008	S57MW009	S57MW010
Acetone								
Benzene								
cis-1,2-Dichloroethene	620		46	47			85	150
1,1-Dichloroethane				1.7			4	4.3
1,2-Dichloroethane								
1,1-Dichloroethene			6.7	11			28	13
Diethyl ether	320	570			750	1300		
Methlyene chloride								
o-Xylene								
Tetrachloroethene	6.3							
trans-1,2-Dichloroethene	3.7							
1,1,1-Trichloroethane	20		4.6					
Trichloroethene	12000		250	280	0.6		480	330
Vinyl chloride	26							5.5

Notes:
Blank - Not detected.

TABLE 1-14

SUMMARY OF POSITIVE DETECTIONS - GROUNDWATER
SITE 57 - FORMER DRUM LOADING AREA
IHDIV-NSWC, INDIAN HEAD, MARYLAND

Analyte	S57MW011	S57MW012	S57MW013	S57TW014	S57TW015	S57TW016	S57TW017	S57TW018
Acetone				70				
Benzene								
cis-1,2-Dichloroethene	30	1.9						64
1,1-Dichloroethane		5.3						2.2
1,2-Dichloroethane			4.8					
1,1-Dichloroethene		2	74					3.7
Diethyl ether	1700			740	920	5.4	4800	2.1
Methlyene chloride								1.3
o-Xylene								
Tetrachloroethene					7.1		1.6	
trans-1,2-Dichloroethene								
1,1,1-Trichloroethane								
Trichloroethene	94	1.6			2.3	1.1		210
Vinyl chloride								

Notes:
Blank - Not detected.

TABLE 1-14

SUMMARY OF POSITIVE DETECTIONS - GROUNDWATER
SITE 57 - FORMER DRUM LOADING AREA
IHDIV-NSWC, INDIAN HEAD, MARYLAND

Analyte	S57TW018-D	S57TW019	S57MW020	S57TW021	S57MW022	S57MW023
Acetone						
Benzene						900
cis-1,2-Dichloroethene	68	5.5			1400	
1,1-Dichloroethane	1.9					
1,2-Dichloroethane						
1,1-Dichloroethene	2.5					
Diethyl ether		77	18			
Methlyene chloride		1.9				
o-Xylene						28
Tetrachloroethene						
trans-1,2-Dichloroethene						
1,1,1-Trichloroethane						
Trichloroethene	210	62				30
Vinyl chloride					1500	

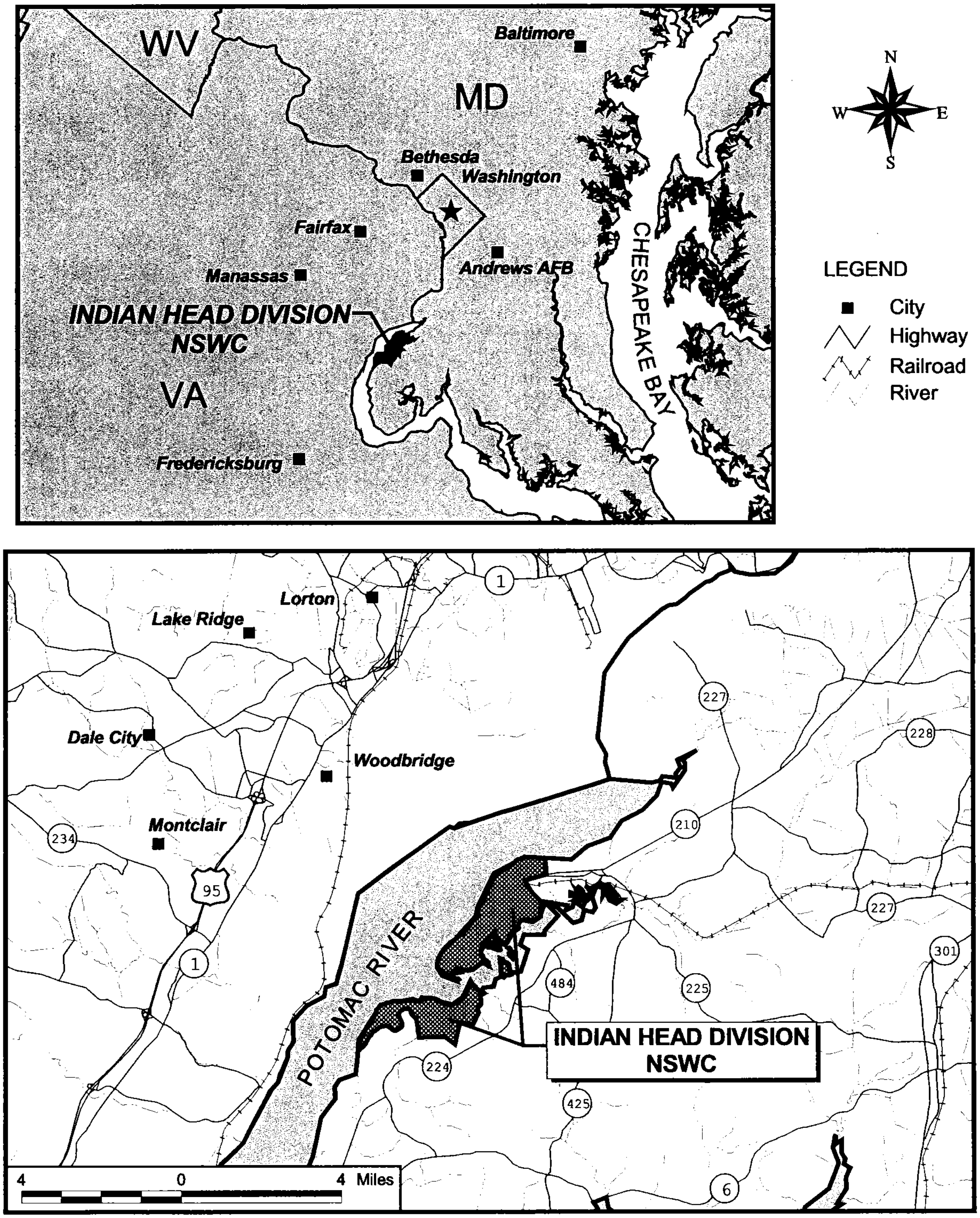
Notes:
Blank - Not detected.

TABLE 1-15

SUMMARY OF THE GRAIN SIZE DISTRIBUTION IN SUBSURFACE SOIL SAMPLES
SITE 57 - FORMER DRUM LOADING AREA
IHDIV-NSWC, INDIAN HEAD, MARYLAND

Sample #	Sample Depth (feet)	Hydraulic Unit	USCS	Soil Description
57SB0160103	4 - 5	Vadose	SM	Sand with some clay, gravel, and silt.
57SB0160303	18 - 20	Lower Surficial Aquifer	SW/SM	Well-graded sand with trace silt and clay.
57SB0180103	4 - 5	Vadose	SM	Clayey sand with some gravel and silt.
57SB0180303	16 - 18	Lower Surficial Aquifer	SM	Sand with some clay and trace silt.
57SB0210103	4 - 5	Vadose	ML	Sandy clay with some silt trace gravel.
57SB0210303	14 - 16	Lower Surficial Aquifer	SP/SM	Poorly graded sand with trace silt and clay.
57SB0220103	4 - 5	Vadose	SM	Sand with some gravel and clay and trace silt.
57SB0220303	12 - 14	Lower Surficial Aquifer	SP/SM	Poorly graded gravelly sand with trace silt and clay.
57SB0240103	4 - 5	Vadose	ML	Sandy silt with some clay trace gravel.
57SB0300203	8 - 10	Surficial Aquifer	SM	Sand with some clay and silt trace gravel.
57SB0300403	22 - 24	Aquitard	ML	Clay with some silt and sand.
57SB0310203	8 - 10	Surficial Aquifer	SM	Sand with some silt and clay trace gravel.
57SB0310403	18 - 20	Aquitard	SM	Sand with some silt and clay.
57SB0320203	8 - 10	Aquitard	ML	Clay with some silt, sand, and gravel.
57SB0320403	18 - 20	Aquitard	ML	Clay with some silt, sand, and gravel.

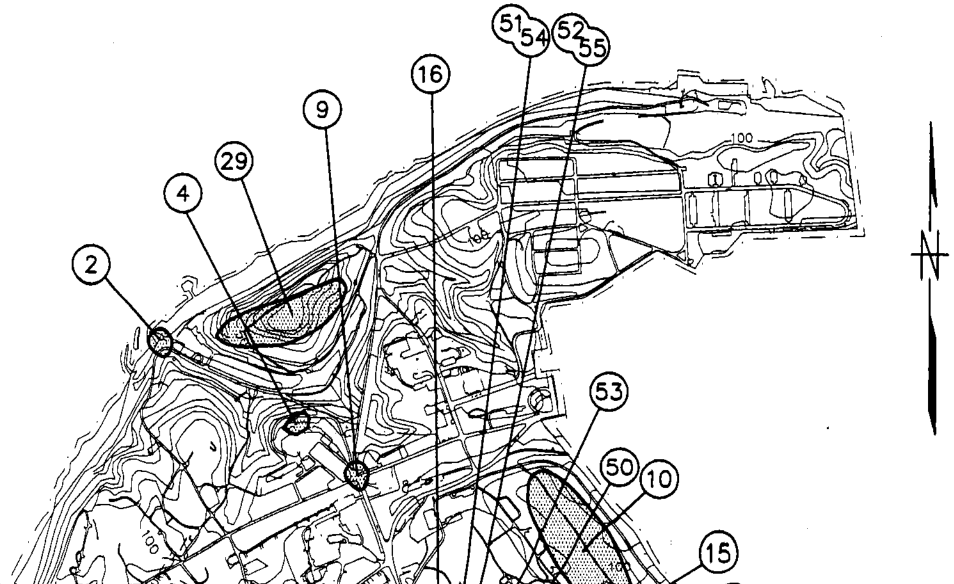
USCS - Unified Soil Classification System.



DRAWN BY	DATE	Tetra Tech NUS, Inc.	CONTRACT NUMBER	OWNER NO.
J. LAMEY	8/2/01		4020	0805
CHECKED BY	DATE		APPROVED BY / GJL	DATE / 8/3/01
GJL	8/3/01	FACILITY LOCATION MAP INDIV - NSWC, INDIAN HEAD, MARYLAND	APPROVED BY / —	DATE / —
COST/SCHEDULE-AREA				
SCALE AS NOTED			DRAWING NO. FIGURE 1 - 1	REV 0

P:\GIS\NSWC_INDIAN_HEAD\SITE42_SITE_LOCATION.APR FACILITY LOCATION MAP LAYOUT 4/11/02 AJ

ACAD: 4020CM03.dwg 04/10/02 HJB PIT



9	Patterson Avenue, Oil Spill
10	Single-base Propellant Grains Spill
11	Caffee Road Landfill
12	Town Gut Landfill
13	Paint Solvents Disposal Ground
14	Waste Acid Disposal Pit
15	Mercury Deposits in Manhole, Flourine Lab
16	Laboratory Chemical Disposal
17	Disposal Metal Parts Along Shoreline
18	Hog Island
19	Catch Basins at Chip Collection Houses
20	Single-base Powder Facilities
21	Bronson Road Landfill
22	NG Slums Burning Site
23	Hydraulic Oil Spill Discharges From Extrusion Plant
24	Abandoned Drain Lines
42	Olsen Road Landfill
43	Toluene Disposal Site
44	Soak Out Area
45	Abandoned Drums
46	Cadmium Sandblast Grit
47	Mercuric Nitrate Disposal Area
48	Nitroglycerine Plant Disposal Area
49	Chemical Disposal Area
50	Building 103, Crawl Space
51	Building 101, Dry Well
52	Building 102, Dry Well
53	Mercury Contamination of the Sewage System
54	Building 101
55	Building 102
56	IW87 – Lead Contamination
57	**TCE Building 292 Area**

APPROXIMATE SITE LOCATION

INTERMITTENT STREAM

NAVAL RESERVE BOUNDARY

100 CONTOUR INTERVAL 10 FEET

FLOW DIRECTION

0 1800 3600

SCALE IN FEET

DRAWN BY HJB DATE 4/10/02	Tetra Tech NUS, Inc.	CONTRACT NO. 4020	OWNER NO. 0805
CHECKED BY KCT DATE 4/25/02	SITE LOCATION MAP SITE 57 – FORMER DRUM LOADING AREA IHDIV–NSWC, INDIAN HEAD, MARYLAND	APPROVED BY KCT	DATE 4/25/02
COST/SCHED-AREA		APPROVED BY	DATE
SCALE AS NOTED		DRAWING NO. FIGURE 1-2	REV. 0

FORM CADD NO. TtNUS_BV.DWG - REV 0 - 1/20/98

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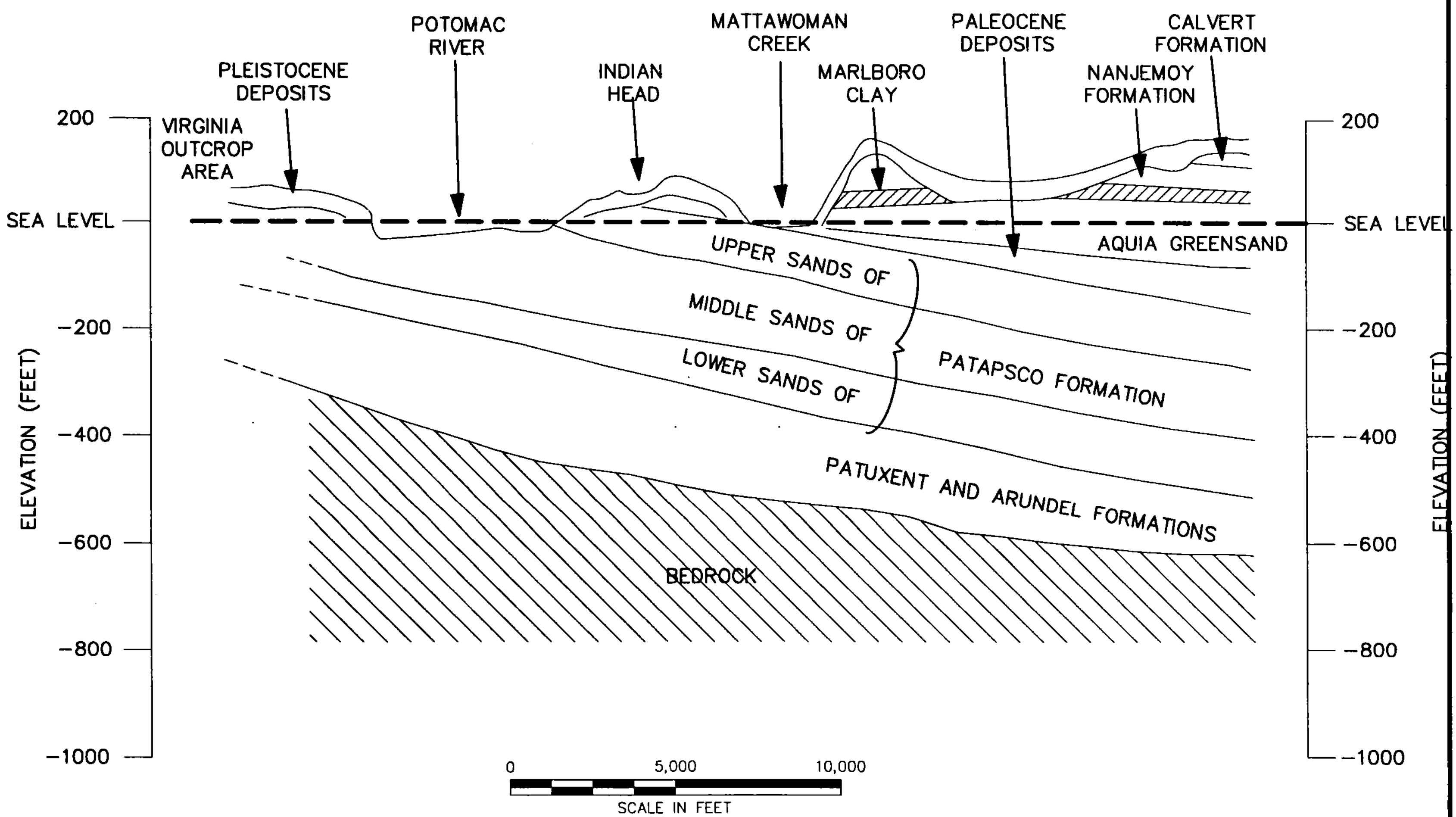
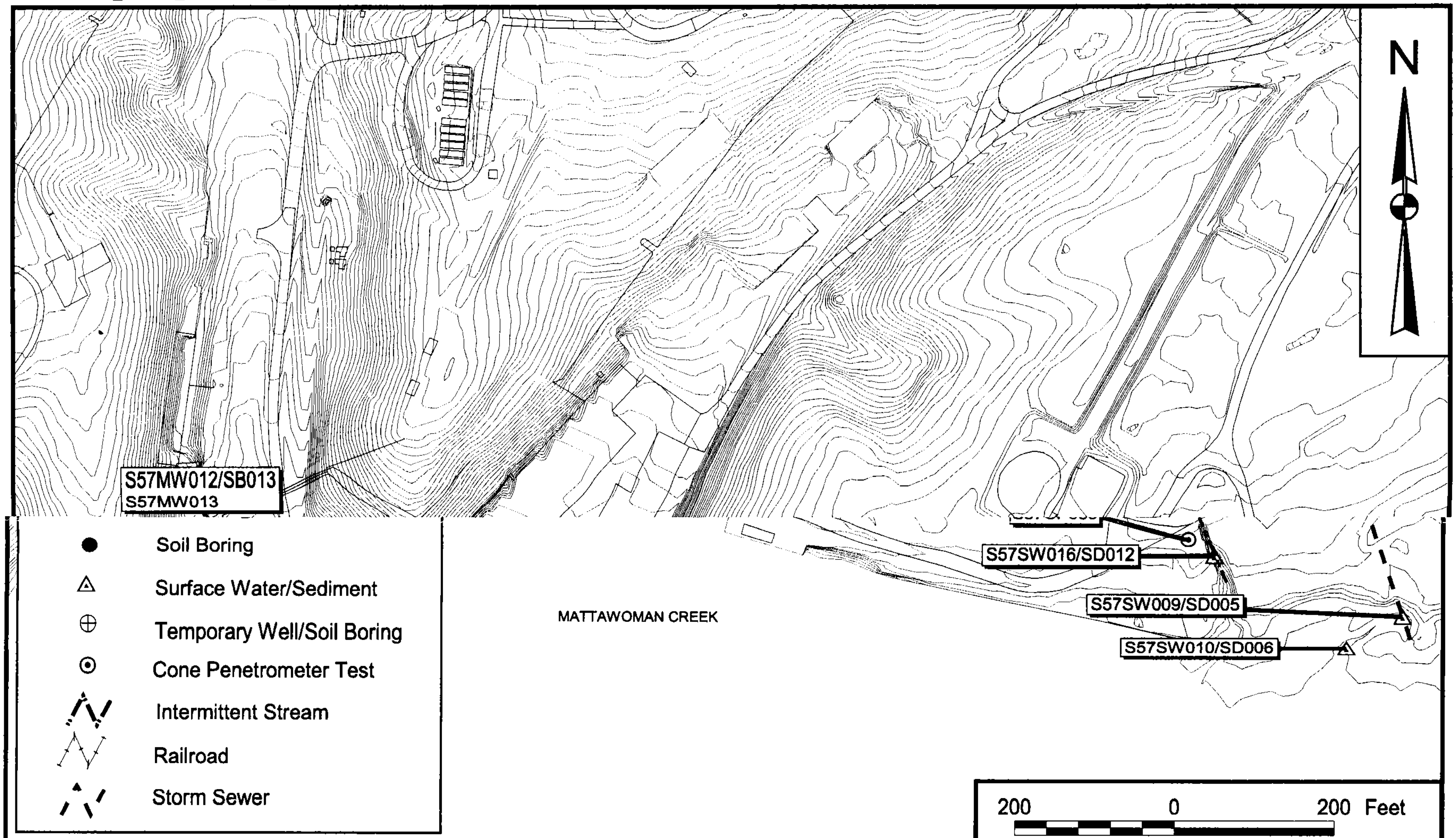


DRAWN BY HJB DATE 4/10/02	Tetra Tech NUS, Inc.	CONTRACT NO. 4020	OWNER NO. 0805
CHECKED BY KCT DATE 4/25/02	GENERALIZED CROSS-SECTION OF THE REGION IHDIV-NSWC, INDIAN HEAD, MARYLAND	APPROVED BY KCT	DATE 4/25/02
COST/SCHED-AREA		APPROVED BY	DATE
SCALE AS NOTED		DRAWING NO. FIGURE 1-3	REV. 0

FORM CADD NO. TtNUS_AH.DWG - REV 0 - 1/22/98

P:\GIS\NSWC_INDIAN_HEAD\7129_SITE57.APR\SITE CONDITIONS MAP LAYOUT 4/11/02 AJ



DRAWN BY J. BELLONE	DATE 2/1/00	Tetra Tech NUS, Inc.	CONTRACT NUMBER 4020	OWNER NUMBER 805
CHECKED BY G. Latulippe	DATE 2/2/00	SITE CONDITIONS MAP SITE 57 - FORMER DRUM LOADING AREA IHDIV - NSWC INDIAN HEAD, MARYLAND	APPROVED BY G. LATULIPPE	DATE 2/2/00
COST/SCHEDULE-AREA			APPROVED BY —	DATE —
SCALE AS NOTED			DRAWING NO. FIGURE 1 - 4	REV 0

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES	NO.	RELEASED FOR	BY	DATE

DRAWN BY MF DATE 3/8/02
CHECKED BY DATE
COST/SCHED-AREA
SCALE AS NOTED

Tetra Tech NUS, Inc.

SOIL AND GROUNDWATER SAMPLING, GEOLOGIC CROSS SECTION, AND CONE PENETROMETER TEST LOCATIONS
SITE 57–FORMER DRUM LOADING AREA
INDIAN HEAD DIVISION NSWC
INDIAN HEAD, MARYLAND

CONTRACT NO. 4020
OWNER NO.
APPROVED BY DATE
APPROVED BY DATE
DRAWING NO. FIGURE 1–5 REV. 0

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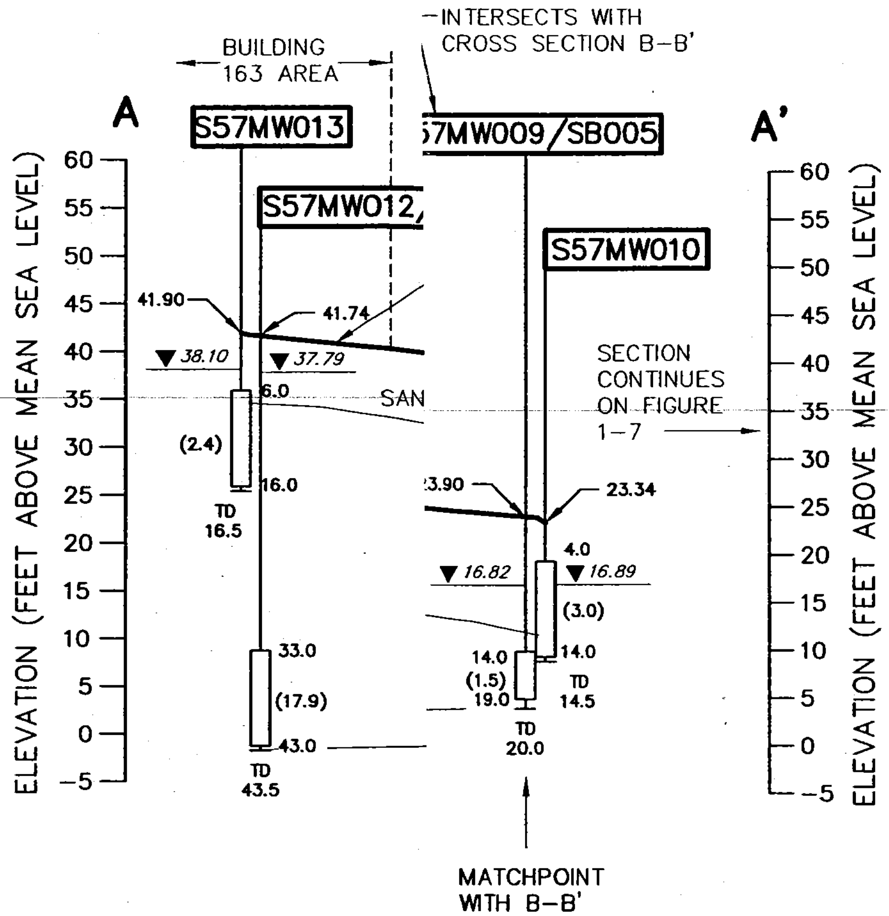
ACAD: 4020GX03.dwg 04/01/02 HJB PIT



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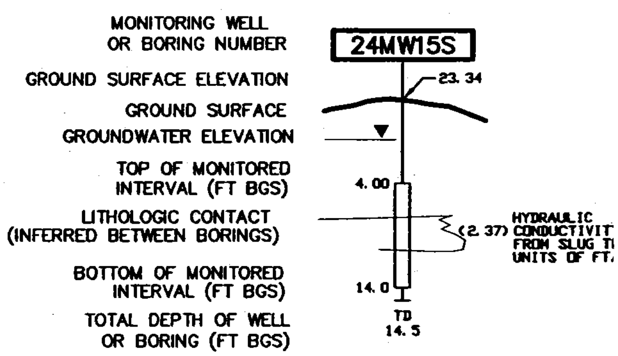
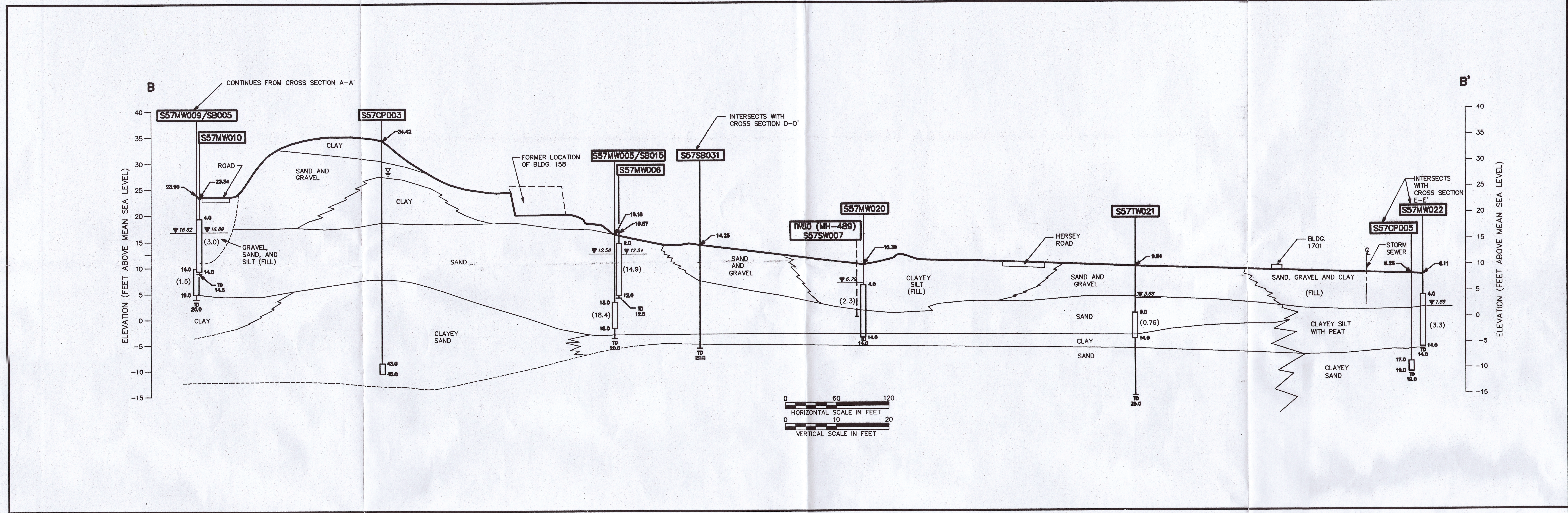


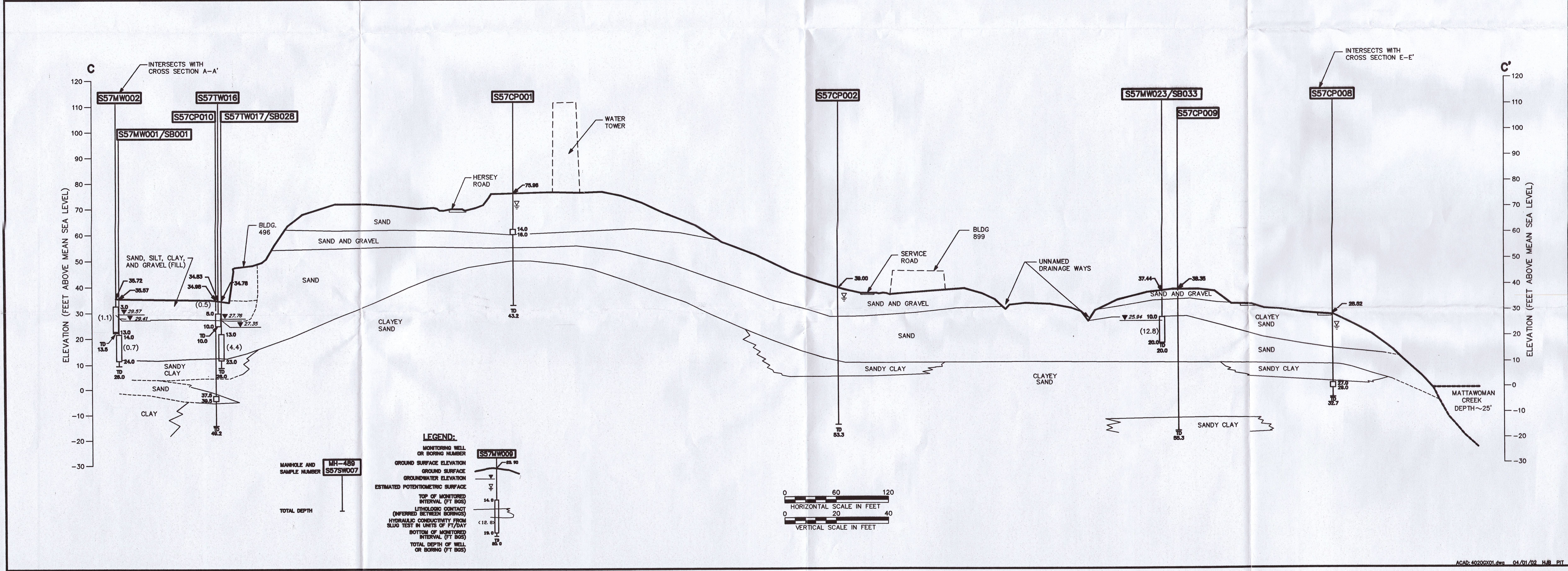
NO.	DATE	REVISIONS

REA

CONTRACT NO. 4020	OWNER NO. 0550
APPROVED BY KCT	DATE 4/25/02
APPROVED BY	DATE
DRAWING NO. FIGURE 1–6	REV. 0

FORM CADD NO. TTNUS-BH.DWG – REV 0 – 9/9/98





ACAD: 40200X01.dwg 04/01/02 HJB PIT

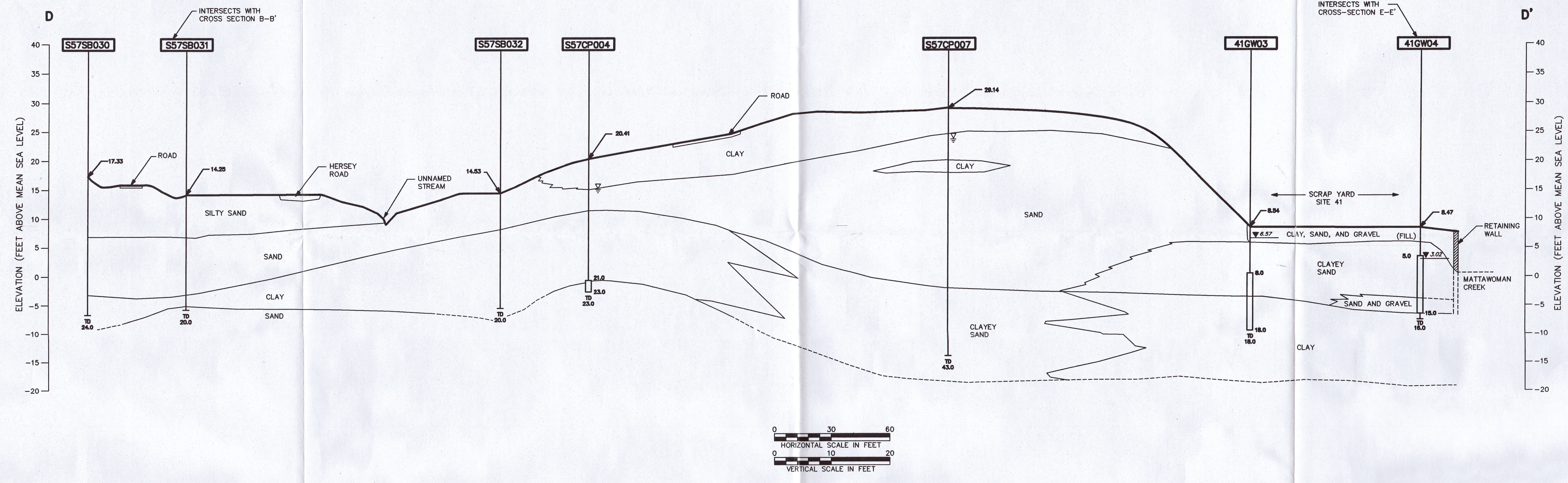
REVISIONS

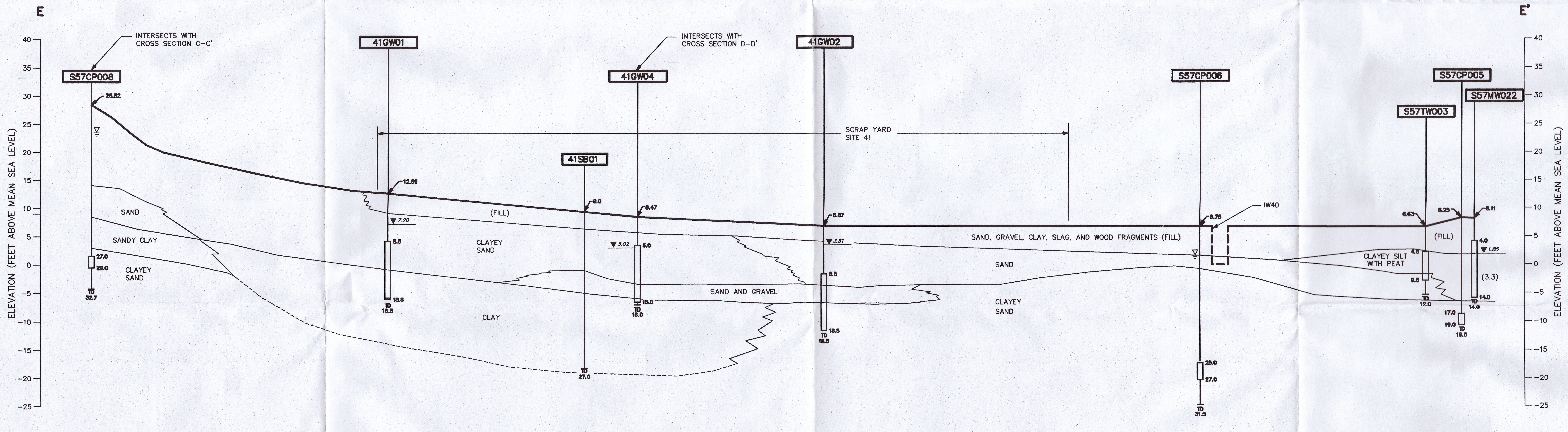
DEPARTMENT OF THE NAVY
NAVAL FACILITIES ENGINEERING COMMAND
ENGINEERING FIELD ACTIVITY–CHESAPEAKE
WASHINGTON, D.C.
NAVAL SURFACE WARFARE CENTER INDIAN HEAD DIVISION
INDIAN HEAD, MD.

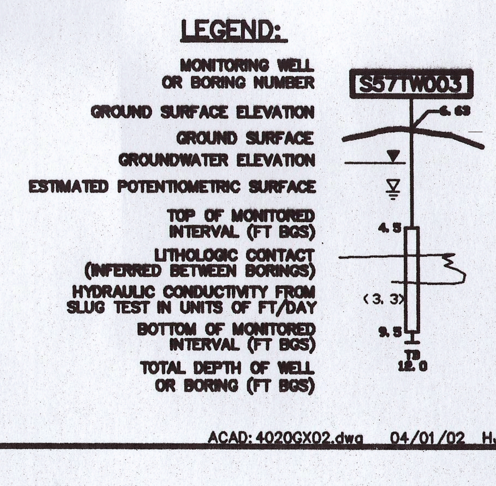
GENERALIZED GEOLOGIC CROSS SECTIONS B–B' AND C–C'
SITE 57 – FORMER DRUM LOADING AREA

CODE I.D. NO. 80091
DRAWING SIZE: D
CONST. CONT. NO.
SPEC.
NAVFAC DRAWING NO. ---

FIGURE 1–7







DEPARTMENT OF THE NAVY
NAVAL FACILITIES ENGINEERING COMMAND

ENGINEERING FIELD ACTIVITY-CHESAPEAKE

NAVAL SURFACE WARFARE CENTER INDIAN HEAD DIVISION
INDIAN HEAD, MD.

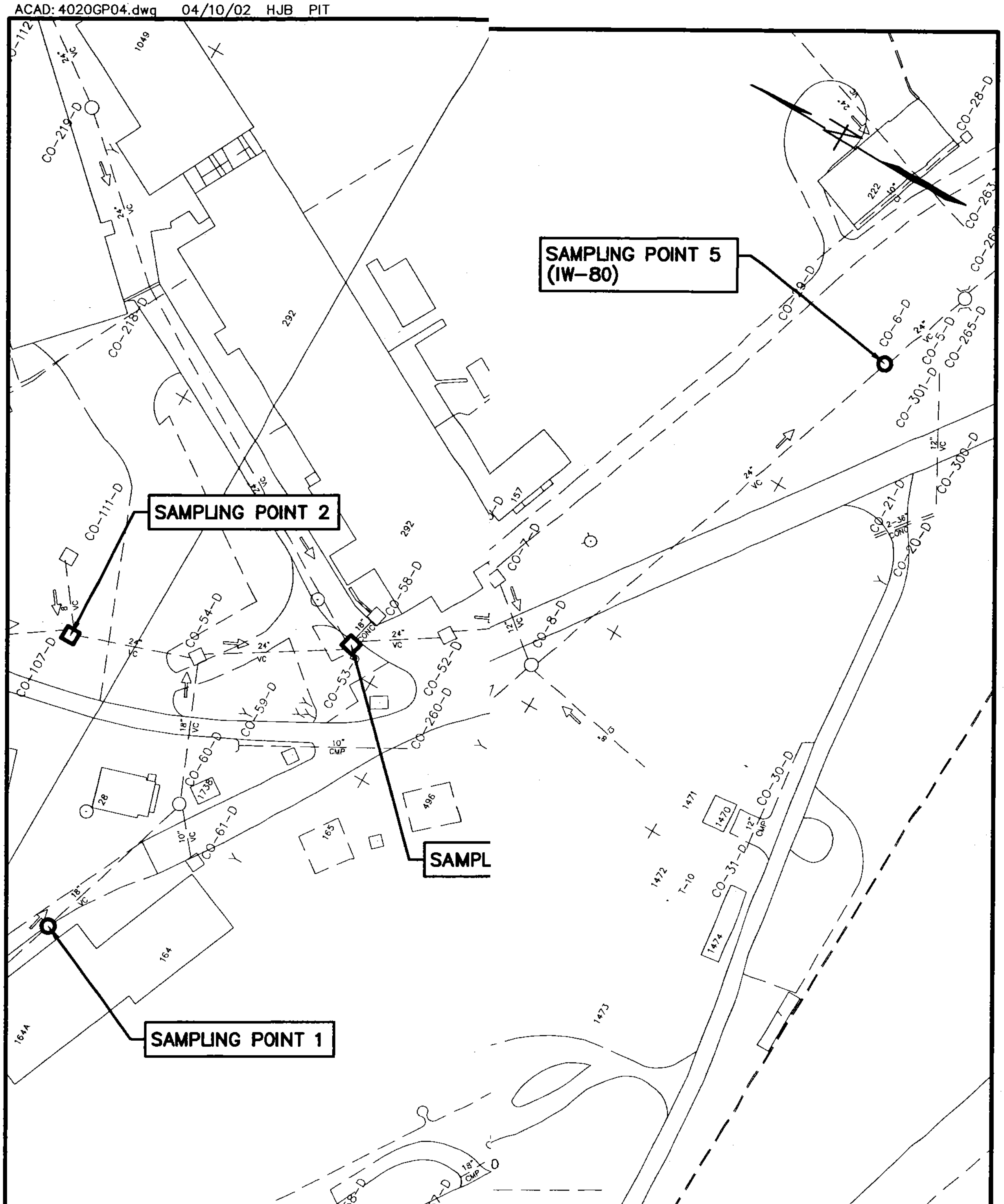
GENERALIZED GEOLOGIC CROSS SECTIONS D-D' AND E-E'
SITE 57 – FORMER DRUM LOADING AREA

CODE I.D. NO. 80091
DRAWING SIZE: D
CONST. CONT. NO.
SPEC.
NAVFAC DRAWING NO.

FIGURE 1-8

ACAD: 4020GX02.dwg 04/01/02 HJB PIT

ACAD: 4020GP04.dwg 04/10/02 HJB PIT

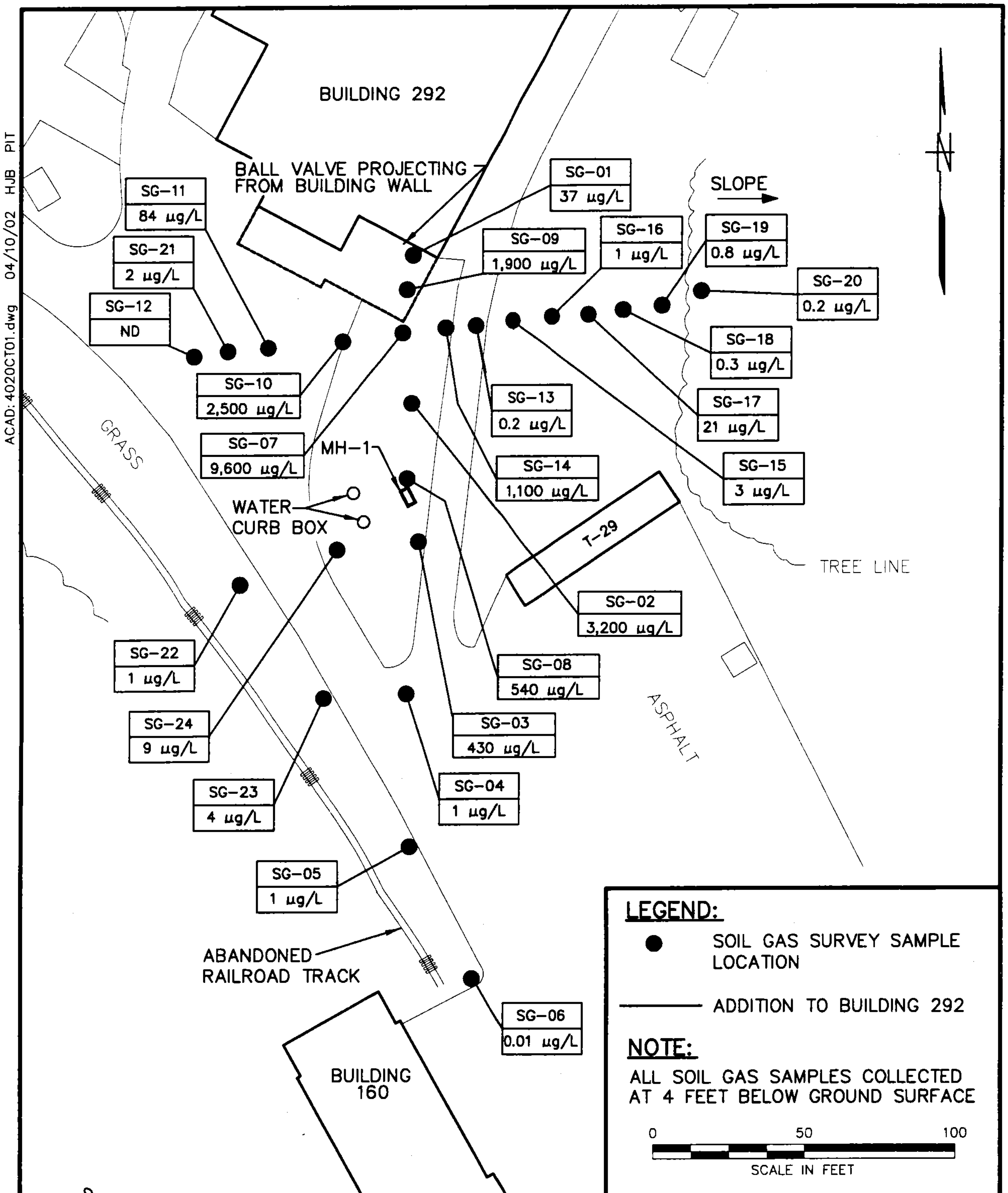


NO.	DATE	REVISIONS

...ING POINTS
...AREA
...AND

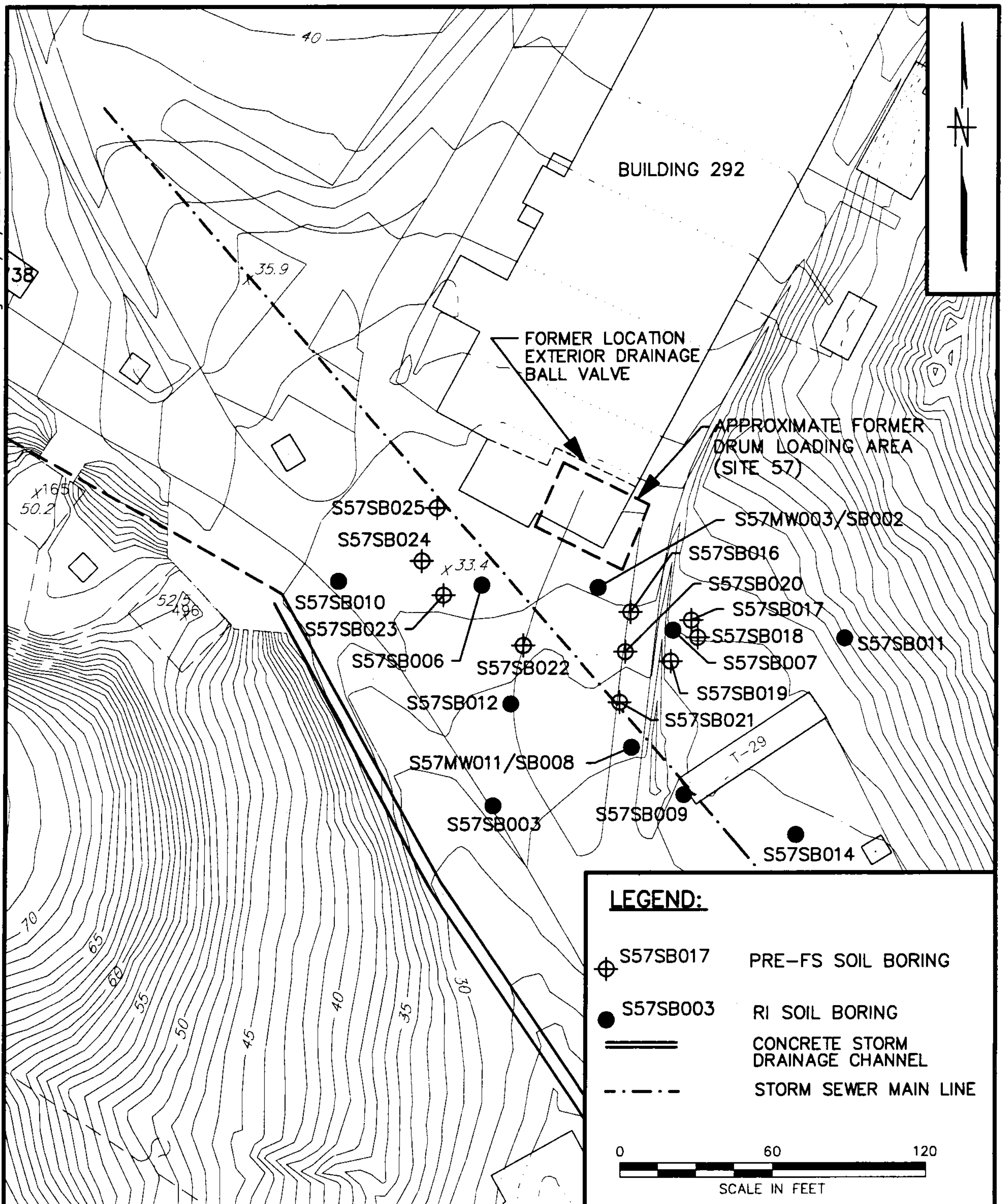
CONTRACT NO. 4020	OWNER NO. 0805
APPROVED BY Ker	DATE 4/25/02
APPROVED BY	DATE
DRAWING NO. FIGURE 1-10	REV. 0

FORM CADD NO. TtNUS_BH.DGN - REV 0 - 1/20/98



DRAWN BY HJB	DATE 4/10/02	Tetra Tech NUS, Inc.	CONTRACT NO. 4020	OWNER NO. 0805
CHECKED BY KCT	DATE 4/25/02	TCE SOIL GAS RESULTS SITE 57–FORMER DRUM LOADING AREA IHDIV–NSWC INDIAN HEAD, MARYLAND	APPROVED BY KCT	DATE 4/25/02
COST/SCHED–AREA			APPROVED BY	DATE
SCALE AS NOTED			DRAWING NO. FIGURE 1–11	REV. 0

FORM CADD NO. TtNUS_AV.DWG - REV 0 - 1/22/98



DRAWN BY MF	DATE 3/13/02	Tetra Tech NUS, Inc.	CONTRACT NO. 4020	OWNER NO.
CHECKED BY KCT	DATE 4/25/02	HOT SPOT SOIL SAMPLING LOCATIONS SITE 57–FORMER DRUM LOADING AREA INDIAN HEAD DIVISION NSWC INDIAN HEAD, MARYLAND	APPROVED BY KCT	DATE 4/25/02
COST/SCHED-AREA			APPROVED BY	DATE
SCALE AS NOTED			DRAWING NO. FIGURE 1–12	REV. 0

FORM CADD NO. SOUTH_AV.DWG – REV 0 – 02/07/97

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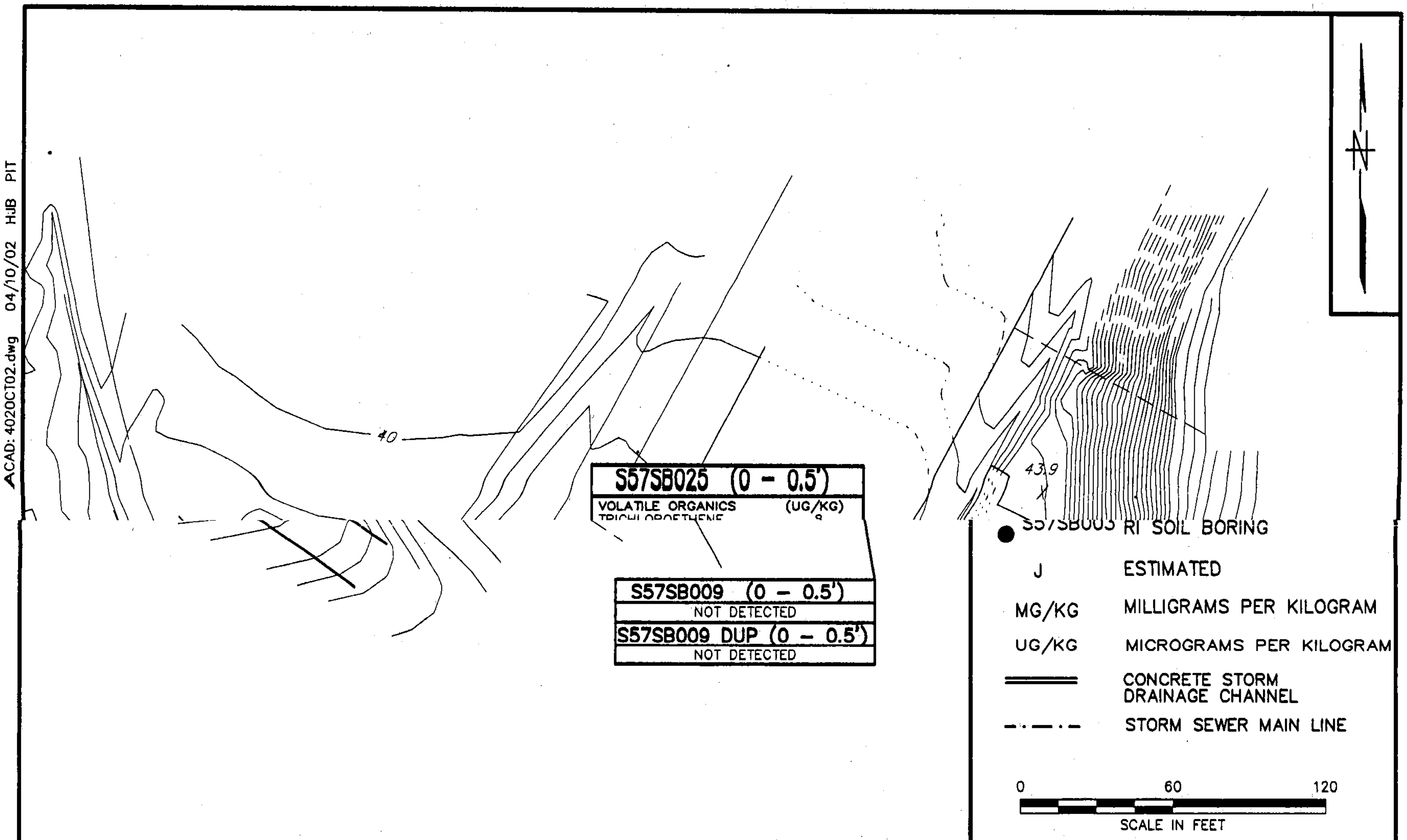
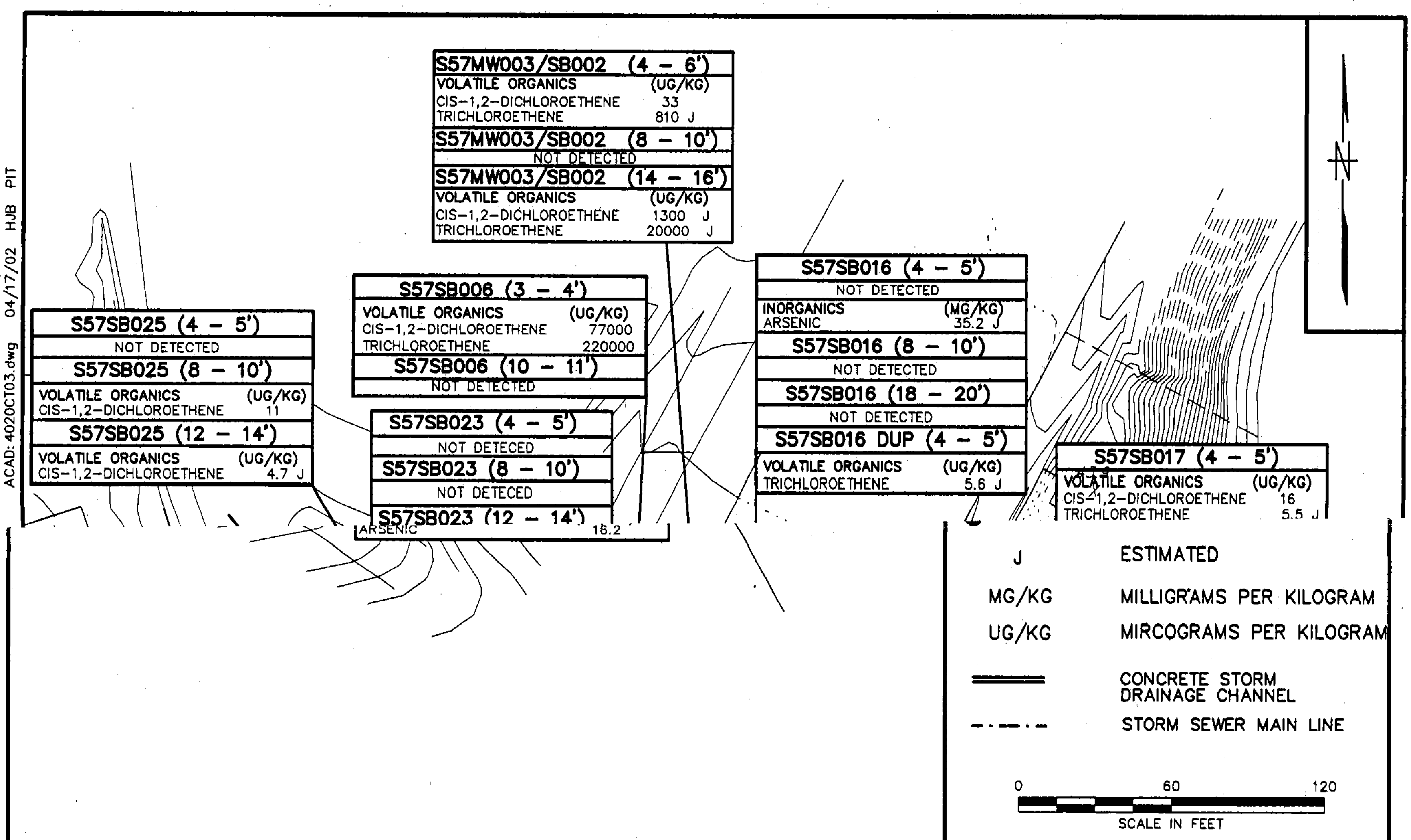


DRAWN BY HJB DATE 4/10/02	**Tetra Tech NUS, Inc.**	CONTRACT NO. 4020 / OWNER NO. 0805
CHECKED BY KCT DATE 4/20/02	SURFACE SOIL COCs – POSITIVE DETECTIONS SITE 57–FORMER DRUM LOADING AREA IHDIV–NSWC, INDIAN HEAD, MARYLAND	APPROVED BY KCT DATE 4/25/02
COST/SCHED–AREA		APPROVED BY DATE
SCALE AS NOTED		DRAWING NO. FIGURE 1–13 REV. 0

FORM CADD NO. TtNUS_BV.DWG – REV 0 – 1/20/98



ACAD: 4020CT03.dwg 04/17/02 HJB PIT

DRAWN BY HJB DATE 4/10/02	Tetra Tech NUS, Inc.	CONTRACT NO. 4020	OWNER NO. 0805
CHECKED BY KCT DATE 4/25/02	SUBSURFACE SOIL COCs – POSITIVE DETECTIONS SITE 57 – FORMER DRUM LOADING AREA IHDIV–NSWC, INDIAN HEAD, MARYLAND	APPROVED BY KCT	DATE 4/25/02
COST/SCHED–AREA		APPROVED BY	DATE
SCALE AS NOTED		DRAWING NO. FIGURE 1–14	REV. 0

FORM CADD NO. TtNUS_BV.DWG – REV 0 – 1/20/98

2.0 REMEDIAL ACTIONS AND OBJECTIVES

2.1 INTRODUCTION

This section presents the objectives for remedial action and the factors used to develop remedial actions. These factors are the preliminary remediation goals (PRGs) that propose clean-up goals and regulatory requirements and guidance (Applicable or Relevant and Appropriate Requirements or ARARs) that may potentially govern remedial actions. In addition, this section presents the COCs and the conceptual pathways through which these chemicals may adversely affect human health and the environment.

This FS addresses soil and groundwater. There were no unacceptable risks to human health from exposure to surface water or sediment. The only potential risks to ecological receptors were associated with Mattawoman Creek. The chemicals that pose unacceptable ecological risks are probably not site related. These chemicals will be addressed in the Mattawoman Creek watershed study.

2.2 REMEDIAL ACTION OBJECTIVES

Based on the potential pathways, receptors of concern, and current and potential future land use scenarios, the remedial action objectives (RAOs) for Site 57 are as follows:

- Prevent exposure to soil contaminated above PRGs.
- Prevent exposure to groundwater contaminated above PRGs.
- Prevent or minimize further migration of the groundwater contaminant plume (plume containment).
- Prevent or minimize further migration of contaminants from soil to groundwater.
- Restore groundwater to its expected beneficial use (aquifer restoration).

These RAOs were developed following guidance provided by EPA, Land Use in the CERCLA Remedy Selection Process (EPA, 1995). According to this guidance, RAOs developed during the RI/FS should reflect the reasonably anticipated future land use or uses. RAOs for groundwater were developed following guidance provided by EPA, Guidance on Remedial Actions for Contaminated Groundwater at Superfund Sites (EPA, 1988a). According to this guidance, the goal of Superfund remediation is to protect human health and the environment by restoring groundwater to its beneficial uses within a reasonable time frame, given the particular site circumstances.

2.3 COMPLIANCE WITH ARARs

One of the primary concerns during the development of remedial action alternatives under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) is the degree of human health and environmental protection afforded by a given remedy. Section 121 of CERCLA requires that primary consideration be given to remedial alternatives that attain or exceed ARARs. The purpose of this requirement is to make CERCLA response actions consistent with other pertinent federal and state environmental regulations. On-site actions need only comply with substantive requirements (e.g., design standards). Off-site actions must comply with substantive and administrative requirements (e.g., permits and recordkeeping). The term "on site" means the areal extent of contamination and all suitable areas in very close proximity to the contamination necessary for implementation of the response action.

ARARs consist of the following:

- Any standard, requirement, criterion, or limitation under federal environmental law.
- Any promulgated standard, requirement, criterion, or limitation under a state environmental or facility siting law that is more stringent than the associated federal standard, requirement, criterion, or limitation.

Definition of the two types of ARARs and to be considered (TBC) criteria are as follows:

- <u>Applicable Requirements</u> means those clean-up standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that directly and fully address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site.

- <u>Relevant and Appropriate Requirements</u> means those clean-up standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that, although not applicable, address problems or situations sufficiently similar (relevant) to those encountered at the CERCLA site that their use is well suited (appropriate) to the particular site.

- <u>TBC Criteria</u> are non-promulgated, non-enforceable guidelines or criteria that may be useful for developing remedial action alternatives and for determining action levels that are protective of human health or the environment.

Section 121(d)(4) of CERCLA allows the selection of a remedial alternative that will not attain ARARs if any of six conditions for a waiver of ARARs exist. These conditions are as follows: the remedial action is an interim measure whereby the final remedy will attain the ARAR upon completion; compliance will result in greater risk to human health and the environment than other options; compliance is technically impracticable; an alternative remedial action will attain the equivalent of the ARAR; for state requirements, the state has not consistently applied the requirement in similar circumstances; and compliance with the ARAR will not provide a balance between protecting public health, welfare, and the environment at the facility with the availability of funds. The last condition only applies to Superfund-financed actions.

ARARs fall into three categories, based on the manner in which they are applied. The characterization of these categories is not perfect, because many requirements are combinations of the three types of ARARs. The categories are as follows:

- Chemical Specific: Health- or risk-based numerical values or methodologies that establish concentration or discharge limits for particular contaminants. Chemical-specific ARARs govern the extent of site cleanup.

- Location Specific: Restrictions based on the concentration of hazardous substances or the conduct of activities in specific locations. Some examples of specific locations include floodplains, wetlands, historic places, and sensitive ecosystems or habitats. These ARARs may restrict or preclude certain remedial actions and may apply only to certain portions of the site.

- Action Specific: Technology- or activity-based controls or restrictions on activities related to management of hazardous substances. Action-specific ARARs pertain to implementing a given remedy.

2.3.1 Chemical-Specific ARARs and TBC Criteria

This section presents a summary of federal and state chemical-specific ARARs and TBC criteria that provide medium-specific guidance on acceptable or permissible concentrations of contaminants. Table 2-1 presents a summary of these ARARs and TBC criteria.

2.3.1.1 Federal

The Safe Drinking Water Act (SDWA) [42 United States Code (USC) 300f et seq.] promulgated National Primary Drinking Water Standard Maximum Contaminant Levels (MCLs) [40 Code of Federal Regulations (CFR) 141]. MCLs are enforceable standards for contaminants in a public drinking water supply system. They consider not only health factors but also the economic and technical feasibility of removing a contaminant from a water supply system. EPA has also promulgated Maximum Contaminant Level Goals (MCLGs) for several organic and inorganic contaminants in drinking water. MCLGs are non-enforceable guidelines that do not consider the technical feasibility of contaminant removal. Secondary MCLs

(SMCLs) (40 CFR 143) are not enforceable but are intended as guidelines for contaminants that may adversely affect the aesthetic quality of drinking water. This includes taste, odor, color, and appearance, which may deter public acceptance of drinking water provided by public water systems. MCLs may be relevant and appropriate for developing groundwater remediation goals. MCLGs and SMCLs may be TBC criteria for developing such goals.

EPA Health Advisories are non-enforceable guidelines developed by the Office of Drinking Water for chemicals that may be intermittently encountered in public water systems. Health advisories are available for short-term, long-term, and lifetime exposures for a 10-kilogram (kg) child and a 70-kg adult. Health advisories may be pertinent TBC criteria for developing groundwater remediation goals, especially for chemicals that are not regulated under the SDWA.

EPA Ambient Water Quality Criteria (AWQC) are non-enforceable guidelines that were developed pursuant to Section 304(a) of the Clean Water Act (CWA) for pollutants in surface water. Although AWQC are not legally enforceable, they have been used by some states to develop enforceable water-quality standards. These guidelines should be considered as potential ARARs, as specified by CERCLA. AWQC are available for the protection of human health from exposure from both drinking water and consuming aquatic organisms (primarily fish) and from consumption of organisms alone. AWQC are also available for the protection of freshwater and saltwater aquatic life. AWQC can be used to establish groundwater clean-up goals that are protective of surface water. AWQC may also be considered for actions that involve groundwater treatment and discharge to surface water.

EPA Reference Doses (RfDs) are estimates (with uncertainty spanning perhaps an order of magnitude) of the amount of a chemical to which humans (including sensitive receptors) can be subjected on a daily basis for a lifetime without appreciable risk of adverse health effects. While not strictly a TBC criterion to be met by remedial alternatives, RfDs can be used to develop remediation goals and to determine areas of a site that pose an unacceptable risk to human health.

EPA Cancer Slope Factors (CSFs) are used to estimate the lifetime probability of humans developing cancer from exposure to known or suspected carcinogens. While not strictly a TBC criterion to be met by remedial alternatives, CSFs can be used to develop remediation goals and to determine areas of a site that pose an unacceptable risk to human health.

EPA Generic Soil Screening Levels (SSLs) are guidance that provides soil concentrations for protection of human health and for migration to groundwater. SSLs are risk-based concentrations derived from equations combining exposure information assumptions with EPA toxicity data. SSLs for migration to groundwater are derived from a simple linear equilibrium soil-water partition equation to estimate contaminant release in soil leachate. SSLs are TBC criteria that can be used to determine areas of a site where soil may be a continuing source of groundwater contamination.

2.3.1.2 State

Maryland Drinking Water Regulations [Code of Maryland Regulations (COMAR) 26.04.01)] include MCLs for inorganic and organic chemicals in drinking water. These standards may be relevant and appropriate for alternatives that involve groundwater cleanup.

Maryland Surface Water Quality Criteria (COMAR 26.08.02.03) establish minimum standards for surface quality for each designated use. Standards are available for protection of human health and protection of aquatic life. These standards may be applicable for alternatives that involve or affect surface water.

Maryland Clean-up Standards for Soil and Groundwater are guidance used as TBC criteria. The clean-up standards are intended to represent concentration levels at which no further remedial action would be required at a property based upon the harm posed by hazardous substances to human health within the constraints of current knowledge. The clean-up standards have been developed by incorporating applicable land uses and the current or projected use of groundwater for potable use.

2.3.2 Location-Specific ARARs and TBC Criteria

This section presents a summary of federal and state location-specific ARARs and TBC criteria that provide restrictions on activities at specific locations. Table 2-2 presents a summary of these ARARs and TBC criteria.

2.3.2.1 Federal

The Endangered Species Act of 1978 (16 USC 1531 et seq. and 50 CFR 402) provides for consideration of the impacts on endangered and threatened species and their critical habitats. The act requires federal agencies, in consultation with the Secretary of the Interior, to ensure any action authorized, funded, or carried out by the agency is not likely to jeopardize the continued existence of any endangered or threatened species or adversely affect its critical habitat. There are no known endangered or threatened species or their critical habitats at Site 57.

The Fish and Wildlife Coordination Act (16 USC 661 et seq.) provides for consideration of the impacts on wetlands and protected habitats. The acts require that federal agencies, before issuing a permit or undertaking a federal action for the modification of any body of water, consult with the appropriate state agency exercising jurisdiction over wildlife resources to conserve those resources.

Federal Protection of Wetlands Executive Order (E.O. 11990) provides for the consideration of wetlands during remedial actions. E.O. 11990 requires federal agencies, in carrying out their responsibilities, to take action to minimize the destruction, loss, or degradation of wetlands and to preserve and enhance the natural and beneficial values of wetlands. 40 CFR 6 Appendix A contains EPA policy for implementing the provisions of E.O. 11990. Mitigation of adverse effects to wetlands must be implemented if the wetlands will be disturbed by remedial activities. There are no wetlands at Site 57.

Federal Floodplain Management Executive Order (E.O. 11988) provides for consideration of floodplains during remedial actions. E.O. 11988 requires federal agencies, in carrying out their responsibilities, to take action to avoid adverse effects, minimize potential harm, and restore and preserve the natural and beneficial values of floodplains. 40 CFR 6 Appendix A contains EPA policy for implementing the provisions of E.O. 11988. Site 57 is not located within a floodplain.

The Archeological and Historic Preservation Act (16 USC 470 et seq.) provides for the preservation of historical and archeological data that might otherwise be lost because of alterations of the terrain. If activities in connection with any federal construction project or federally approved project may cause irreparable loss to significant scientific, historic, or archeological data, the agency undertaking the project must preserve the data or request the Department of Interior to do so. There are no known historical or archeological areas at Site 57.

EPA Groundwater Protection Strategy and Classification Guidelines (EPA, 1986) provides guidance in determining the potential beneficial uses of contaminated groundwater. The various groundwater classes are described as follows:

- Special groundwater (Class I) is highly vulnerable to contamination and is either an irreplaceable or ecologically vital source of drinking water.

- Current and potential sources of drinking water and water having other beneficial uses include all other groundwater that is currently used (Class IIA) or is potentially available (Class IIB) for drinking water, agriculture, or other beneficial use.

- Groundwater not considered a potential source of drinking water and of limited beneficial use (Class III) is saline or is otherwise contaminated by naturally occurring constituents or human activity that is not associated with a particular waste disposal activity or another site beyond levels that allow remediation using methods reasonably employed in public water treatment systems. Class III also includes groundwater that is not available in sufficient quantity at any depth to meet the needs of an average household.

The groundwater at Site 57 would be classified as Class IIB.

2.3.2.2 State

Maryland Threatened and Endangered Species Regulations (COMAR 08.03.08) provides for consideration of the impacts on endangered, threatened, and rare species and their critical habitats. There are no known endangered, threatened, or rare species or their critical habitats at Site 57.

Maryland Regulations on Construction on Nontidal Waters and Floodplains (COMAR 26.17.04) are designed to govern construction, reconstruction, repair, alteration of a dam, reservoir, or water obstruction, or any change of the course, current, or cross-section of a stream or body of water. This includes changes to the 100-year floodplain of free-flowing waters. Remedial alternatives for Site 57 are not expected to impact surface water bodies. Site 57 is not located within a floodplain.

Maryland Nontidal Wetland Regulations (COMAR 26.23) contain permit requirements for activities in nontidal wetlands. The intent of the requirements is to avoid adverse impacts and minimize losses of nontidal wetlands. There are no nontidal wetlands at, or that could be affected by, remedial activities at Site 57.

Maryland Tidal Wetland Regulations (COMAR 26.24) contain permit requirements for activities in tidal wetlands. The intent of the requirements is to avoid adverse impacts and minimize losses of tidal wetlands. There are no tidal wetlands at, or that could be affected by, remedial activities at Site 57.

2.3.3 Action-Specific ARARs and TBC Criteria

This section presents a summary of federal and state action-specific ARARs and TBC that may pertain to implementation of a remedial activity. Table 2-3 presents a summary of these ARARs and TBC criteria.

2.3.3.1 Federal

The Clean Air Act (CAA) (42 USC 7401 et seq.) consists of programs or requirements that may be ARARs, depending on the nature of the remedial action and the amount and types of air emissions that may be discharged. These programs include National Ambient Air Quality Standards (NAAQS) (40 CFR 50), National Emissions Standards for Hazardous Air Pollutants (NESHAPS) (40 CFR 61 and 63), and New Source Performance Standards (NSPS) (40 CFR 60).

EPA requires the attainment and maintenance of primary and secondary NAAQS to protect public health and welfare, respectively. NAAQS are available for six criteria pollutants (carbon monoxide, lead, nitrogen oxides, ozone, sulfur dioxide, and airborne particulates). These standards are not source specific but are national limitations on ambient air quality. States are responsible for assuring compliance with NAAQS. Requirements in an EPA-approved State Implementation Plan for the implementation, maintenance, and enforcement of NAAQS are potential ARARs. NAAQS might be relevant and appropriate for emissions of particulates from remedial activities related to contaminated soils at a site or emissions from soil and groundwater treatment processes.

NESHAPs are emissions standards for source types (i.e., industrial categories) that emit hazardous air pollutants and include significant sources of beryllium, vinyl chloride, benzene, asbestos, and other hazardous substances. NESHAPs might be relevant and appropriate for emissions of hazardous air pollutants from treatment of contaminated soil or groundwater.

NSPS are established for new sources of air emissions to ensure that new stationary sources minimize emissions. These standards are for categories of stationary sources that cause or contribute to air pollution that might endanger public health or welfare. Standards are based on the best-demonstrated available technology. NSPS may be relevant and appropriate for treatment of contaminated soil or groundwater if the pollutant(s) emitted and the technology used during the clean-up action are sufficiently similar to the pollutant and source category regulated by the NSPS and are well suited to the circumstances at the site.

Control of Air Emissions from Superfund Air Strippers at Superfund Groundwater Sites (OSWER Directive 9344.0-28) is a TBC that guides the control of air emissions from air strippers. For sites located in areas that are not attaining NAAQS for ozone, add-on emissions controls are required for an air stripper with an actual emission rate in excess of 3 pounds per hour, an actual emission rate in excess of 15 pounds per day, or a potential emission rate of 10 tons per year of total VOCs. Generally, the guidelines are suitable for VOC air emissions from other vented extraction techniques (e.g., soil vapor extraction) but not from area sources (e.g., soil excavation). Charles County, Maryland is in a nonattainment area for ozone.

Resource Conservation and Recovery Act (RCRA) Subtitle C (42 USC 6921 et seq.) regulates the treatment, storage, and disposal of hazardous waste from its generation to its ultimate disposal. In general, RCRA Subtitle C requirements will be applicable if either of the following apply:

- The waste is a listed or characteristic hazardous waste and was treated, stored, or disposed after the effective date of the RCRA requirements under consideration.

- The activity at a CERCLA site constitutes current treatment, storage, or disposal of hazardous waste as defined by RCRA.

RCRA Subtitle C requirements may be relevant and appropriate when the waste is sufficiently similar to a hazardous waste or the on-site remedial action includes treatment, storage, or disposal. In addition, the particular RCRA requirement should be well suited to the circumstances of the contaminant release and site.

The spent TCE associated with operations at Building 292 at Site 57 is a listed RCRA hazardous waste. The following requirements of RCRA Subtitle C may pertain to remedial actions at Site 57:

- Identification and listing of hazardous waste (40 CFR 261).
- Hazardous waste generator requirements (40 CFR 262).
- Transportation requirements (40 CFR 263).
- Standards for treatment, storage, and disposal (TSD) facilities (40 CFR 264), including corrective action management units (CAMUs) and temporary units (TUs).
- Land disposal restrictions (40 CFR 268).

Identification and Listing of Hazardous Waste (40 CFR 261) defines characteristic and listed hazardous wastes that are subject to RCRA Subtitle C.

Standards Applicable to Generators of Hazardous Waste (40 CFR 262) include manifest, pre-transport (i.e., packaging, labeling, placarding), recordkeeping, and reporting requirements.

Standards for Transporters of Hazardous Waste (40 CFR 263) are applicable to off-site transport of hazardous waste. These regulations include requirements for compliance with the manifest and recordkeeping systems and requirements for immediate action and cleanup of spills during transport.

Standards for Owners and Operators of Hazardous Waste TSD Facilities (40 CFR 264) are potentially applicable to remedial actions involving hazardous waste. Standards for TSD facilities include requirements for releases from solid waste management units (SWMUs), closure and post-closure care, use and management of containers, and design and operating standards for tank systems, surface impoundments, waste piles, landfills, incinerators, and miscellaneous units. When a site, or portion thereof, receives a CAMU designation, the designated area qualifies for certain exemptions from RCRA Subtitle C requirements. A temporary unit or staging pile that will only be used for a short time during remediation also qualifies for certain exemptions.

Land Disposal Restriction (LDR) Requirements (40 CFR 268) restrict certain hazardous wastes from being placed or disposed on the land unless they meet specific treatment standards. Removal and treatment of a RCRA hazardous waste or movement outside a CAMU, thereby constituting disposal, may trigger LDR requirements. LDRs are not triggered when hazardous remediation waste is placed in a CAMU, when remediation wastes generated at a facility outside a CAMU are consolidated into a CAMU, and when remediation wastes are moved between two or more CAMUs. In addition, remediation wastes can be excavated from a CAMU, treated in a separate unit, and redeposited in the CAMU without triggering LDRs.

RCRA Subtitle D (42 USC 6941 et seq.) establishes minimum design and operating criteria for solid (nonhazardous) waste landfills. In general, this applies to landfills that receive municipal solid waste as defined in 40 CFR 258, codispose sewage sludge with municipal solid waste, receive nonhazardous municipal solid waste combustion ash, or are not regulated under RCRA Subtitle C. None of the above situations would apply to remedial alternatives for Site 57.

The CWA (33 USC ss/1251 et seq.) governs point-source discharges to surface water through the National Pollutant Discharge Elimination System (NPDES), the discharge of dredged or fill material to surface water, and spills of oil and hazardous substances to surface water. NPDES requirements (40 CFR 122) are potentially applicable if the direct discharge of pollutants into surface water is part of the remedial action. This includes the discharge of stormwater from certain construction and other industrial activities. Dredge and fill requirements (40 CFR 230 to 232) may be applicable if fill materials are deposited into surface water.

Underground Injection Control Program (40 CFR 144 to 148) contains provisions for control and prevention of pollutant injection into groundwater. Class IV wells are used to inject hazardous waste into or above a formation that, within ¼ mile of the well, contains an underground source of drinking water. Operation or construction of Class IV wells is prohibited and allowed only for the reinjection of treated groundwater as part of a CERCLA or RCRA cleanup. The regulations are potentially applicable if groundwater is removed, treated, and reinjected into the formation from which it was withdrawn.

2.3.3.2 State

Maryland Ambient Air Quality Standards (COMAR 26.11.04) establish ambient standards for particulate matter, sulfur oxides, carbon monoxide, ozone, sulfur compounds, nitrogen dioxide, lead, and fluoride. These standards may be applicable for emissions of fugitive dust and other criteria pollutants that may be generated during groundwater treatment or soil excavation, handling, or treatment.

Maryland General Emission Standards, Prohibitions, and Restrictions (COMAR 26.11.06) establish emission standards for visible emissions, particulate matter, carbon monoxide, sulfur compounds, VOCs, and fluoride. These regulations also control NSPS sources by reference to federal regulations (40 CFR 60). These standards may be applicable for emissions of fugitive dust and other regulated pollutants that may be generated during groundwater treatment or soil excavation, handling, or treatment.

Maryland Regulations for Toxic Air Pollutants (COMAR 26.11.15 and 26.11.16) are standards for industries that emit toxic air pollutants, including sources regulated under NESHAPs (40 CFR 61 and 63). These standards might be relevant and appropriate for emissions of toxic or hazardous air pollutants from treatment of contaminated groundwater or contaminated soil.

Maryland Regulations for Disposal of Controlled Hazardous Substances (COMAR 26.13) are similar to the federal RCRA Subtitle C hazardous waste regulations. The regulations include identification and listing of hazardous wastes and standards for generators, transporters, and TSD facilities. These regulations would be potentially applicable for any hazardous waste generated during remedial activities and would be potentially relevant and appropriate for handling of nonhazardous waste.

Maryland Regulations for Solid Waste Management (COMAR 26.04.07) establish standards for disposal of solid waste. The regulations include minimum design features for caps for municipal landfills, land-clearing debris landfills, rubble landfills, and industrial waste landfills. These regulations would not be ARARs for the conditions at Site 57.

Maryland Water Pollution Permit Regulations (COMAR 26.08.04) contain requirements for discharges to surface water, including general discharge permits for certain classes of stormwater discharges from construction and other industrial activities. These requirements are potentially applicable for discharges to surface water.

Maryland Water Management Regulations include requirements for erosion and sediment control (COMAR 26.17.01) and stormwater management (COMAR 26.17.02). Federal projects do not require an erosion and sediment control plan; however, the design standards and specifications may be relevant and appropriate for land clearing, grading, or other earth disturbances. The regulations for stormwater management apply to the development of land for residential, commercial, industrial, or institutional. The stormwater management provisions would not be ARARs for the conditions at Site 57.

Maryland Well Construction Regulations (COMAR 26.04.04) establish design standards and procedures applicable to construction of wells, including monitoring wells. The regulations contain construction and abandonment standards that are applicable to remedial activities that include groundwater extraction or monitoring.

Maryland Underground Injection Control Regulations (COMAR 26.08.07) incorporates the EPA underground injection control program regulations by reference (40 CFR 124, 144, and 146), with certain exceptions.

2.4 PRELIMINARY REMEDIATION GOALS

2.4.1 Soil

PRGs for soil were developed based on protection of human health and for protection of groundwater.

The baseline human risk assessment, which is summarized in Section 1.3.8, identified potential unacceptable risks for future construction workers and hypothetical future residents exposed to soil. Future residential use of Site 57 is unlikely and is not a reasonably anticipated future land use scenario. However, PRGs were developed assuming residential use in order to evaluate alternatives that would allow for unlimited use and unrestricted exposure. Carcinogenic risks for the future construction workers exposed to soil were within the EPA acceptable risk range (1E-04 to 1E-06). Carcinogenic risks for hypothetical future child and adult residents exceeded the acceptable risk range, and arsenic was the main contributor to the unacceptable risk. The hazard index (HI) exceeded 1.0 for construction worker and resident receptors for the RME scenario, and arsenic was the main contributor to the HI. Therefore, PRGs only need to be developed for arsenic for protection of human health. Calculations are provided in Appendix F. Based on an HI of 1.0, the PRG for arsenic for the future construction worker is 65 mg/kg. The PRG for arsenic for the hypothetical future child resident is 22.5 mg/kg. A PRG was not calculated for a future adult resident because the concentration would be higher than for the child resident.

Soil PRGs for protection of groundwater are based on the lower of the EPA generic SSLs and Maryland Department of the Environment (MDE) guidance values for protection of groundwater, both based on a dilution and attenuation factor (DAF) of 10, which is consistent with MDE guidance. Table 2-4 presents a comparison of the maximum soil COPC concentrations, EPA SSLs, and MDE guidance values. Based on the comparisons in Table 2-4, PRGs for protection of groundwater have been developed for cis-1,2-dichloroethene (200 µg/kg) and TCE (28 µg/kg). Although the maximum concentrations of methylene chloride, benzo(a)anthracene, benzo(b)fluoranthene, and arsenic are higher than EPA SSLs based on a DAF of 10, these chemicals were not detected in groundwater. Therefore, a soil PRG to protect groundwater is not warranted. There is no EPA SSL or MDE guidance value for lead. Lead is not a COPC for groundwater; therefore, a soil PRG for lead is not warranted.

how does this lead to ~~[illegible]~~ ?

2.4.2 Groundwater

Groundwater at Site 57 is not a source of drinking water. However, the goal of Superfund remediation is to return usable groundwaters to their beneficial uses wherever practicable. In addition, the selected remedy for a site must also attain ARARs, unless a waiver is justified. Table 2-5 presents a summary of maximum groundwater COPC concentrations compared to potential ARARs, including MCLs and MDE guidance values. The maximum concentrations of cis-1,2-dichloroethene, 1,1-dichloroethene, tetrachloroethene, TCE, and vinyl chloride exceed ARARs. There are no ARARs for diethyl ether; therefore, a risk-based PRG was calculated. The PRG for diethyl ether, a noncarcinogen, is based on an HI that also accounts for the HI contribution from the PRGs for the other COPCs that had concentrations higher than ARARs. The HI based on the PRGs for these chemicals is 0.64. Therefore, the PRG for diethyl ether is based on an HI of 0.36, resulting in a total HI of 1.0 for the child resident, the most sensitive receptor. The calculated PRG for diethyl ether is 1,094 µg/L. Calculations are provided in Appendix F. Appendix F also contains calculations that show that the cancer risk based on the PRGs (ARARs) is within the EPA acceptable risk range (1E-04 to 1E-06). A summary of the groundwater PRGs is as follows:

- Cis-1,2-dichloroethene – 70 µg/L (MCL)
- 1,1-Dichloroethene – 7 µg/L (MCL)
- Diethyl ether – 1,094 µg/L (risk-based)
- Tetrachloroethene – 5 µg/L (MCL)
- Trichloroethene – 5 µg/L (MCL)
- Vinyl chloride – 2 µg/L (MCL)

HI > 1 bad! HI = 1 ? – that is the goal dummy.

2.5 CONTAMINANTS AND MEDIA OF CONCERN

There are no COCs for surface water or sediment because there are no unacceptable risks to human health or the environment from exposure to these media.

Soil COCs were identified based on the information provided in Section 2.4. The soil COC based on protection of human health is arsenic. Soil COCs based on protection of groundwater are the VOCs cis-1,2-dichloroethene and TCE.

Groundwater COCs were identified based on the information provided in Section 2.4. Groundwater COCs based on ARARs (i.e., MCLs) are cis-1,2-dichloroethene, 1,1-dichloroethene, tetrachloroethene, TCE, and vinyl chloride. The groundwater COC based on noncarcinogenic risks is diethyl ether.

2.6 VOLUME OR AREA OF CONTAMINATED MEDIA

2.6.1 Soil

Figure 2-1 shows the surface soil sampling locations near Building 292 where COCs were detected at concentrations higher than PRGs. Figure 2-2 shows the subsurface soil sampling locations near Building 292 where COCs were detected at concentrations higher than PRGs. The areas where arsenic concentrations are higher than PRGs for protection of residential and industrial receptors and where VOC concentrations exceed PRGs for protection of groundwater overlap and are in the same general area. The only exception to this is at location S57SB005 (not shown on Figures 2-1 and 2-2), where arsenic concentrations exceed the residential PRG at the surface and at a depth of 3 to 4 feet bgs. This area is located approximately 400 feet south-southeast from the Building 292 sampling locations. The locations and depths where soil concentrations exceed PRGs are summarized in Table 2-6.

Based on an approximate area of 6,500 square feet and an average depth of contamination of 8 feet, the volume of contaminated soil near Building 292 is estimated to be 1,926 cubic yards. This does not include soil samples collected beneath the water table. Based on an approximate area of 100 square feet and a depth of contamination of 6 feet, the volume of contaminated soil at location S57SB005 is estimated to be 22 cubic yards.

2.6.2 Groundwater

Figure 2-3 shows the groundwater sampling locations where VOCs were detected at concentrations higher than PRGs. The locations where groundwater concentrations exceed PRGs, based on samples collected in 2001, are summarized in Table 2-7.

The length of the groundwater plume between Building 292 and location S57MW006 is approximately 1,050 feet. The plume width is difficult to estimate because few sidegradient wells have been installed at the site, except near Building 292. Most of the wells have been installed near the center of the valley. Based on the topography and geologic cross-sections, the width of the plume is estimated to range from 160 feet near Building 292 to 80 feet near location S57MW006. Based on an average aquifer thickness of 22 feet and a porosity of 0.25, the volume of contaminated groundwater in this area is estimated to be 5.2 million gallons. There is another area of contamination near well S57MW022. There are insufficient wells near this location to estimate the area or volume of groundwater contamination.

TABLE 2-1

CHEMICAL-SPECIFIC ARARs AND TBCs
SITE 57 – FORMER DRUM LOADING AREA
IHDIV-NSWC, INDIAN HEAD, MARYLAND

Act/Authority	Criteria/Issues	Citation	Brief Description	Status	Consideration in the FS
Federal					
Safe Drinking Water Act	Maximum Contaminant Levels (MCLs) and Maximum Contaminant Level Goals (MCLGs)	40 CFR 141	Establishes enforceable standards (MCLs) and non-enforceable goals (MCLGs) for public water systems for contaminants that have been determined to adversely affect human health.	Relevant and appropriate (MCLs) and to be considered (MCLGs)	Considered for determining groundwater remediation goals.
	National Secondary Drinking Water Regulations (SMCLs)	40 CFR 143	Establishes welfare-based standards for public water systems for contaminants that may affect the aesthetic qualities of drinking water.	To be considered	Considered for determining groundwater remediation goals.
EPA Office of Drinking Water	Heatlh Advisories	NA	Establishes short-term, long-term, and lifetime exposure limits for children and adults.	To be considered	Considered for determining groundwater remediation goals.
Clean Water Act	Ambient Water Quality Criteria	40 CFR 131.36	Non-enforceable guidelines for pollutants in surface water.	To be considered	Considered for determining discharge limits to surface water or surface water remediation goals.
Risk Assessment Guidance	Reference Doses and Cancer Slope Factors	NA	Used to estimate risks and can be used to develop risk-based clean-up goals.	To be considered	Considered for determining areas of a site that pose an unacceptable risk.
State					
Water, Ice, and Sanitary Facilities (Environment Article, Title 9)	Drinking Water Quality	COMAR 26.04.01	Establishes drinking water standards for public water systems.	Relevant and appropriate	Considered for determining groundwater remediation goals.

TABLE 2-1

CHEMICAL-SPECIFIC ARARs AND TBCs
SITE 57 – FORMER DRUM LOADING AREA
IHDIV-NSWC, INDIAN HEAD, MARYLAND

Act/Authority	Criteria/Issues	Citation	Brief Description	Status	Consideration in the FS
Water, Ice, and Sanitary Facilities (Environment Article, Title 9)	Surface Water Quality Criteria	COMAR 26.08.02.03	Establishes minimum standards for surface water quality.	Potentially applicable	Considered for determining discharge limits to surface water or surface water remediation goals.
MDE Guidance	Cleanup Standards for Soil and Groundwater	Interim Final Guidance	Guidance for remedial actions based on land use and projected use of groundwater for potable use.	To be considered	Considered for determining remediation goals for soil and groundwater.

TABLE 2-2

LOCATION-SPECIFIC ARARs AND TBCs
SITE 57 – FORMER DRUM LOADING AREA
IHDIV-NSWC, INDIAN HEAD, MARYLAND

Act/Authority	Criteria/Issues	Citation	Brief Description	Status	Consideration in the FS
Federal					
Endangered Species Act	Protection of Endangered Species	16 USC 1531 et seq and 50 CFR 402	This act and associated regulations requires federal agencies to act to avoid jeopardizing the continued existence of federally listed endangered or threatened species.	Not applicable	There are no endangered or threatened species or critical habitats at Site 57.
Fish and Wildlife Coordination Act	Impacts on Fish and Wildlife	16 USC 661	Requires federal agencies to consult appropriate state agencies before structural modification of any body of water, including wetlands. Requires action to be taken to protect fish and wildlife from projects affecting the water body and provides for consideration of impacts on wetlands and protected habitats.	Not applicable	Remedial actions are not expected to impact surface water or wetlands.
Protection of Wetlands	Activities in Wetlands	E.O. 11990 and 40 CFR 6 Appendix A	If no practicable alternative exists to a remedial activity that may adversely affect a wetland, impacts from implementing the chosen alternative must be mitigated.	Not applicable	There are no wetlands at, or that could be affected by, remedial activities at Site 57.
Floodplain Management	Activities in Floodplains	E.O. 11988 and 40 CFR 6 Appendix A	If no practicable alternative exists to performing cleanup in a floodplain, potential harm must be mitigated and actions taken to preserve the beneficial values of the floodplain.	Not applicable	Site 57 is not located within a floodplain.

TABLE 2-2

LOCATION-SPECIFIC ARARs AND TBCs
SITE 57 – FORMER DRUM LOADING AREA
IHDIV-NSWC, INDIAN HEAD, MARYLAND

Act/Authority	Criteria/Issues	Citation	Brief Description	Status	Consideration in the FS
Archeological and Historical Preservation Act of 1974	Historic Areas	16 USC 470 et seq. and 36 CFR 65	Establishes requirements relating to potential loss or destruction of significant scientific, historical, or archeological data as a result of a proposed remedy.	Not applicable	There are no historic or archeological areas at Site 57.
EPA Groundwater Protection Strategy	Groundwater Classification	NA	Provides guidance in determining the potential beneficial uses of contaminated groundwater.	To be considered	Groundwater at Site 57 is Class IIB, potentially available for drinking water, agriculture, or other beneficial uses.
State					
Endangered Species	Threatened and Endangered Species	COMAR 08.03.08	Provides for consideration of the impacts on endangered, threatened, and rare species and their critical habitats.	Not applicable	There are no endangered, threatened, or rare species or critical habitats at Site 57.
Water Resources (Environment Article, Title 5)	Construction on Nontidal Waters and Floodplains	COMAR 26.17.04	Governs water obstructions or changes to a stream or body of water.	Not applicable	Remedial alternatives for Site 57 are not expected to impact surface water bodies. Site 57 is not located in a floodplain.
	Nontidal Wetland Regulations	COMAR 26.23	Establishes requirements for activities in nontidal wetlands.	Not applicable	There are no nontidal wetlands at, or that could be affected by, remedial activities at Site 57.
Wetlands and Riparian Rights (Environment Article, Title 16)	Tidal Wetland Regulations	COMAR 26.24	Establishes requirements for activities in tidal wetlands.	Not applicable	There are no tidal wetlands at, or that could be affected by, remedial activities at Site 57.

TABLE 2-3

ACTION-SPECIFIC ARARs AND TBCs
SITE 57 – FORMER DRUM LOADING AREA
IHDIV-NSWC, INDIAN HEAD MARYLAND

Act/Authority	Criteria/Issues	Citation	Brief Description	Status	Considerations in the FS
Federal					
Clean Air Act	National Ambient Air Quality Standards (NAAQS)	40 CFR 50	Estabishes primary (health-based) and secondary (welfare-based) air quality standards for carbon monoxide, lead, nitrogen oxides, particulate matter, ozone, and sulfur oxides emitted from a major source of emissions.	Potentially relevant and appropriate	Fugitive dust (particulate matter) and other criteria pollutants may be generated during groundwater treatment or soil excavation, handling, or treatment activities.
	New Source Performance Standards (NSPS)	40 CFR 60	Establishes source-specific emission standards.	Potentially relevant and appropriate	Air pollutants may be discharged during groundwater or soil treatment activities.
	National Emission Standards for Hazardous Air Pollutants (NESHAPs)	40 CFR 61 and 40 CFR 63	Establishes emission standards for particular air contaminants from specific sources.	Potentially relevant and appropriate	Hazardous air pollutants may be discharged during groundwater or soil treatment activities.
EPA Superfund Guidance	Control of Air Emissions from Air Strippers	OSWER Directive 9344.0-28	Emission controls are required for an air stripper if actual or potential VOC emission rates are exceeded in an ozone nonattainment area.	To be considered	Charles County, Maryland is in a nonattainment area for ozone. An air stripper could be used for groundwater treatment.
Resource Conservation and Recovery Act (Subtitle C)	Identification and Listing of Hazardous Waste	40 CFR 261	Identifies those solid wastes that are subject to regulation as a hazardous waste.	Potentially applicable	Spent TCE from Building 292 operations is a listed hazardous waste.

TABLE 2-3

ACTION-SPECIFIC ARARs AND TBCs
SITE 57 – FORMER DRUM LOADING AREA
IHDIV-NSWC, INDIAN HEAD MARYLAND

Act/Authority	Criteria/Issues	Citation	Brief Description	Status	Considerations in the FS
Resource Conservation and Recovery Act (Subtitle C)	Standards Applicable to Generators of Hazardous Waste	40 CFR 262	Establishes standards for generators of hazardous waste.	Potentially applicable	These standards would be applicable for hazardous wastes shipped off site for disposal.
	Standards Applicable to Transporters of Hazardous Waste	40 CFR 263	Establishes standards for transportation of hazardous waste.	Potentially applicable	These standards would be applicable for hazardous wastes shipped off site for disposal.
	Standards for Owners and Operators of Hazardous Waste TSD Facilitites	40 CFR 264	Establishes minimum national standards for acceptable management of hazardous waste.	Potentially applicable or relevant and appropriate	These standards would be applicable for on-site treatment or disposal of hazardous waste and relevant and appropriate for nonhazardous waste.
	Land Disposal Restrictions	40 CFR 268	Identifies hazardous wastes that are restricted from land disposal and waste analysis requirements.	Potentially applicable	These restrictions would apply if excavated soil were classified as a hazardous waste.
RCRA (Subtitle D)	Criteria for Municipal Solid Waste Landfills	40 CFR 258	Subpart F contains requirements for closure and post-closure care.	Not applicable	Site 57 does not include a landfill.
Clean Water Act	National Pollutant Discharge Elimination System	40 CFR 122	NPDES permits are required for any discharges to surface waters.	Potentially applicable	Any alternative that includes discharges into surface water would comply with the substantive permit requirements.
	Dredge and Fill	40 CFR 230 to 232	Provides guidelines and regulations related to permitting of discharges of dredge or fill material to surface water.	Not applicable	Remedial activities at Site 57 would not discharge dredge and fill material to surface water.

Act/Authority	Criteria/Issues	Citation	Brief Description	Status	Considerations in the FS
Safe Drinking Water Act	Underground Injection Control Program	40 CFR 144 to 148	Contains provisions for control and prevention of pollutant injection into groundwater.	Potentially applicable	These requirements would be applicable if groundwater is removed, treated, and reinjected into the formation from which it was withdrawn.
State					
Ambient Air Quality Control (Environment Article, Title 2)	Ambient Air Quality Standards	COMAR 26.11.04	Establishes ambient standards for particulate matter, sulfur oxides, carbon monoxide, ozone, nitrogen oxides, lead, and fluoride.	Potentially applicable	Fugitive dust and other criteria pollutants may be generated during groundwater treatment or soil excavation, handling, or treatment activities.
	General Emission Standards, Prohibitions, and Restrictions	COMAR 26.11.06	Establishes emission standards for visible emissions, particulate matter, carbon monoxide, sulfur compounds, VOCs, and fluoride and control of NSPS sources.	Potentially applicable	Fugitive dust and other criteria pollutants may be generated during groundwater treatment or soil excavation, handling, or treatment activities
	Toxic Air Pollutants	COMAR 26.11.15 and 26.11.16	Establishes standards for industries that emit toxic air pollutants, including sources regulated by NESHAPs.	Potentially relevant and appropriate	Hazardous air pollutants may be discharged during groundwater or soil treatment activities.
Hazardous Materials and Hazardous Substances (Environment Article, Title 7)	Identification and Listing of Hazardous Waste	COMAR 26.13.02	Identifies those solid wastes that are subject to regulation as a hazardous waste.	Potentially applicable	Spent TCE from Building 292 operations is a listed hazardous waste.

TABLE 2-3

ACTION-SPECIFIC ARARs AND TBCs
SITE 57 – FORMER DRUM LOADING AREA
IHDIV-NSWC, INDIAN HEAD MARYLAND

Act/Authority	Criteria/Issues	Citation	Brief Description	Status	Considerations in the FS
Hazardous Materials and Hazardous Substances (Environment Article, Title 7)	Standards Applicable to Generators of Hazardous Waste	COMAR 26.13.03	Establishes standards for generators of hazardous waste.	Potentially applicable	These standards would be applicable for hazardous wastes shipped off site for disposal.
	Standards Applicable to Transprorters of Hazardous Waste	COMAR 26.13.04	Establishes standards for transportation of hazardous waste.	Potentially applicable	These standards would be applicable for hazardous wastes shipped off site for disposal.
	Standards for Owners and Operators of Hazardous Waste TSD Facilitites	COMAR 26.13.05	Establishes minimum standards for acceptable management of hazardous waste.	Potentially applicable or relevant and appropriate	These standards would be applicable for on-site treatment or disposal of hazardous waste and relevant and appropriate for nonhazardous waste.
Regulation of Water Supply, Sewage Disposal, and Solid Wastes (Environment Article, Title 9)	Solid Waste Management – Closure of Sanitary Landfills	COMAR 26.04.07	Contains requirements for closure and post-closure care of land disposal facilities.	Not applicable	Site 57 does not include a landfill.
	Water Pollution Permit Regulations	COMAR 26.08.04	Contains requirements for discharges to surface water	Potentially applicable	Any alternative that includes a discharge to surface water would comply with these requirements.
	Water Management Regulations	COMAR 26.17.01	Contains requirements for erosion and sediment control.	Potentially relevant and appropriate	Alternatives that include earth disturbance would comply with these requirements.

TABLE 2-3

ACTION-SPECIFIC ARARs AND TBCs
SITE 57 – FORMER DRUM LOADING AREA
IHDIV-NSWC, INDIAN HEAD MARYLAND

Act/Authority	Criteria/Issues	Citation	Brief Description	Status	Considerations in the FS
Regulation of Water Supply, Sewage Disposal, and Solid Wastes (Environment Article, Title 9)	Water Management Regulations	COMAR 26.17.02	Contains requirements for storm water management during development.	Not applicable	Alternatives would not include land development that would increase storm water runoff.
	Well Construction Regulations	COMAR 26.04.04	Contains design standards and procedures for construction of wells.	Potentially applicable	The requirements would apply to remedial activities that include groundwater monitoring.
Environment Article, Title 7 and Title 9	Underground Injection Control	COMAR 26.08.07	References federal regulations for control and prevention of pollutant injection into groundwater.	Potentially applicable	These requirements would be applicable if groundwater is removed, treated, and reinjected into the formation from which it was withdrawn.

TABLE 2-4

SELECTION OF SOIL PRGs FOR PROTECTION OF GROUNDWATER
SITE 57 – FORMER DRUM LOADING AREA
IHDIV-NSWC, INDIAN HEAD, MARYLAND

Soil COPC	Maximum Concentration	EPA SSL (DAF=10)	MDE Guidance (DAF=10)	Comments
Volatile Organics (µg/kg)				
cis-1,2-Dichloroethene	77,000	200	200	Exceeds both criteria
Methylene chloride	21,000	10	12	Exceeds both criteria but not detected in groundwater
Trichloroethene	220,000	30	28	Exceeds both criteria
Semivolatile Organics (µg/kg)				
Benzo(a)anthracene	2,300	1,000	40,000	Exceeds SSL but not detected in groundwater
Benzo(a)pyrene	1,700	4,000	4,100	Below criteria
Benzo(b)fluoranthene	4,200	2,500	120,000	Exceeds SSL but not detected in groundwater
Dibenzo(a,h)anthracene	350	1,000	380,000	Below criteria
Indeno(1,2,3-cd)pyrene	970	7,000	350,000	Below criteria
Metals (mg/kg)				
Arsenic	103	15	NA	Exceeds SSL but not detected in groundwater
Lead	487	NA	NA	No criteria but not a COC for groundwater

NA Not available.

TABLE 2-5

COMPARISON OF GROUNDWATER CONCENTRATIONS TO ARARs
SITE 57 – FORMER DRUM LOADING AREA
IHDIV-NSWC, INDIAN HEAD, MARYLAND

Groundwater COPC	Maximum Concentration	MCL	MDE Guidance	Comments
Acetone	70	NA	160	Below criteria
cis-1,2-Dichloroethene	1,400	70	70	Above criteria
1,1-Dichloroethane	5.3	NA	160	Below criteria
1,2-Dichloroethane	4.8	5	5	Below criteria
1,1-Dichloroethene	74	7	7	Above criteria
Diethyl ether	4,800	NA	NA	No criteria
Methylene chloride	1.9	5	5	Below criteria
Tetrachloroethene	7.1	5	5	Above criteria
Trans-1,2-Dichloroethene	3.7	100	100	Below criteria
1,1,1-Trichloroethane	20	200	200	Below criteria
Trichloroethene	12,000	5	5	Above criteria
Vinyl chloride	1,500	2	2	Above criteria

All concentrations presented in units of µg/L.
NA Not available.

TABLE 2-6

SUMMARY OF EXCEEDANCES OF SOIL PRGs
SITE 57 – FORMER DRUM LOADING AREA
IHDIV-NSWC, INDIAN HEAD, MARYLAND
PAGE 1 OF 2

Location	Depth (ft)	COC	Concentration[1]	Basis	Comments
S57MW003/SB002	4 – 6	TCE	810 µg/kg	Groundwater protection	
	14 – 16	TCE	20,000 µg/kg	Groundwater protection	Below water table
S57MW009/SB005	0 – 0.5	Arsenic	33.7 mg/kg	Residential use	
	4 – 6	Arsenic	21.3/50 mg/kg	Residential use	
S57SB006	3 – 4	TCE	220,000 µg/kg	Groundwater protection	
		Cis-1,2-DCE	77,000 µg/kg	Groundwater protection	
S57SB007	0 – 0.5	TCE	93 µg/kg	Groundwater protection	
		Arsenic	103 mg/kg	Industrial use	
	4 – 5	TCE	50 µg/kg	Groundwater protection	
		Arsenic	36.2 mg/kg	Residential use	
S57MW011/SB008	0 – 0.5	TCE	64/34 µg/kg	Groundwater protection	
		Arsenic	29.3 mg/kg	Residential use	
	4 – 6	TCE	48/11U mg/kg	Groundwater protection	
	10 – 11	TCE	41 µg/kg	Groundwater protection	Below water table
S57SB011	14 – 15	TCE	31 µg/kg	Groundwater protection	Below water table
S57SB012	3 – 4	TCE	35 µg/kg	Groundwater protection	
	7 – 8	TCE	110 µg/kg	Groundwater protection	
S57SB016	4 – 5	Arsenic	35.2 mg/kg	Residential use	
S57SB017	0 – 0.5	TCE	220/210 µg/kg	Groundwater protection	
S57SB018	4 – 5	TCE	270 µg/kg	Groundwater protection	
S57SB019	0 – 0.5	TCE	49 µg/kg	Groundwater protection	
	4 - 5	TCE	52 µg/kg	Groundwater protection	
	14 - 16	TCE	45 µg/kg	Groundwater protection	Below water table
S57SB020	0 – 0.5	Arsenic	33.6 mg/kg	Residential use	

TABLE 2-6

SUMMARY OF EXCEEDANCES OF SOIL PRGs
SITE 57 – FORMER DRUM LOADING AREA
IHDIV-NSWC, INDIAN HEAD, MARYLAND

Location	Depth (ft)	COC	Concentration(1)	Basis	Comments
S57SB021	0 – 0.5	TCE	53 µg/kg	Groundwater protection	
		Arsenic	79.9 µg/kg	Industrial use	
	4 - 5	TCE	82 µg/kg	Groundwater protection	
	8 - 10	TCE	98/41 µg/kg	Groundwater protection	Below water table?
		Cis-1,2-DCE	690/240 µg/kg	Groundwater protection	Below water table?
S57SB022	8 - 10	TCE	32 µg/kg	Groundwater protection	Below water table?

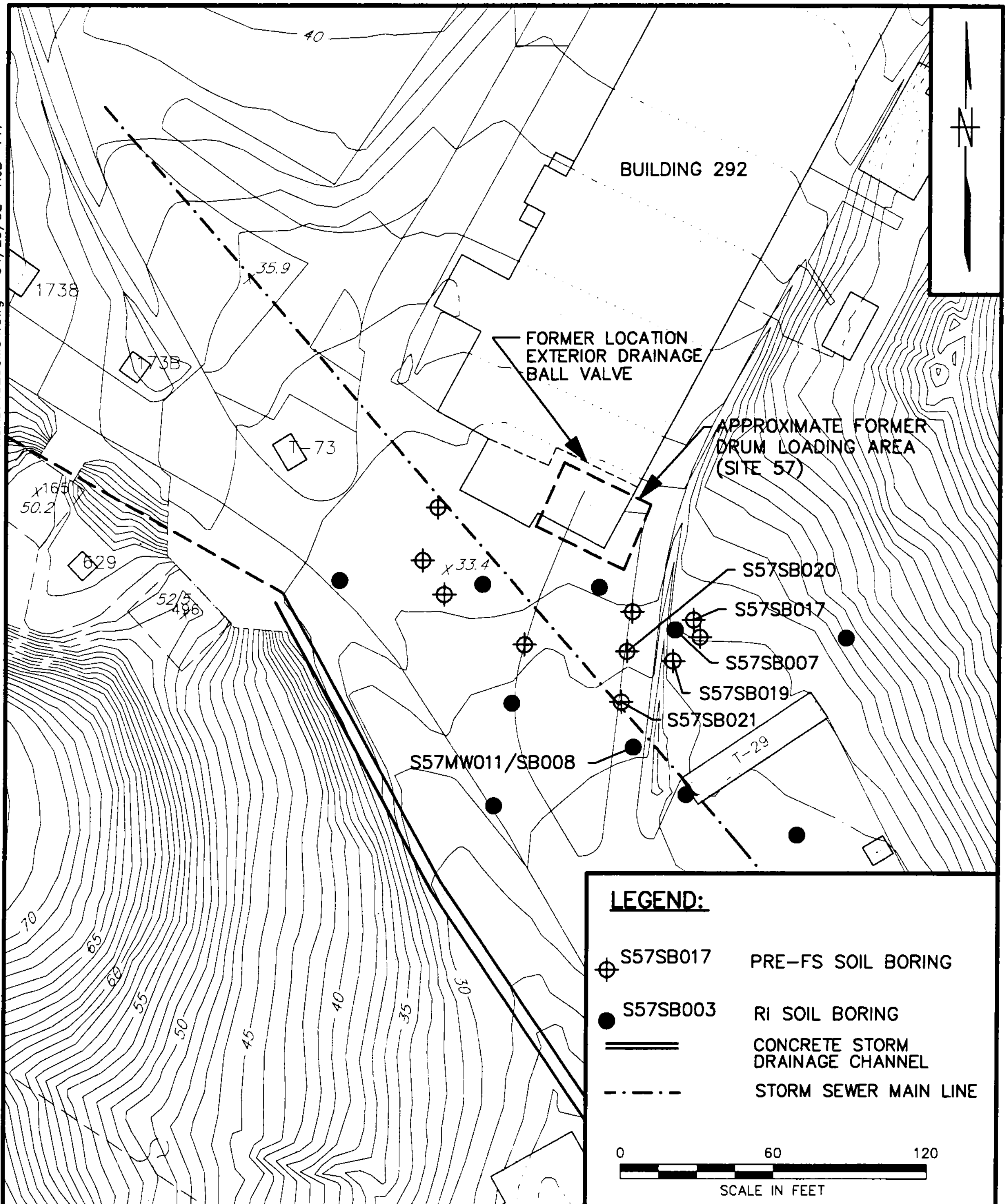
(1) Two results indicate duplicate samples. U = not detected.
Cis-1,2-DCE cis-1,2-dichloroethene
TCE trichloroethene

TABLE 2-7

SUMMARY OF EXCEEDANCES OF GROUNDWATER PRGs
SITE 57 – FORMER DRUM LOADING AREA
IHDIV-NSWC, INDIAN HEAD, MARYLAND

Location and Screened Interval	COC	Concentration (µg/L)	Comments
S57CP005 (lower)	Trichloroethene	11/9.4[1]	Downgradient area
S57MW002 (upper)	Trichloroethene	43	Source area
S57MW003 (lower)	Trichloroethene	450/280[1]	Source area
S57MW004 (upper)	cis-1,2-Dichloroethene	620	Source area
	Tetrachloroethene	6.3	
	Trichloroethene	12,000	
	Vinyl chloride	26	
S57MW006 (upper)	Trichloroethene	250	Mid-plume area
S57MW007 (lower)	1,1-Dichlroethene	11/5U[1]	Source area
	Trichloroethene	280/0.6[1]	
S57MW008 (upper)	Diethyl ether	1,300	Source area
S57MW009 (lower)	1,1-Dichloroethene	28	Mid-plume area
	cis-1,2-Dichloroethene	85	
	Trichloroethene	480	
S57MW010 (upper)	1,1-Dichloroethene	13	Mid-plume area
	cis-1,2-Dichloroethene	150	
	Trichloroethene	330	
	Vinyl chloride	5.5	
S57MW011 (upper)	Diethyl ether	1,700	Source area
	Trichloroethene	94	
S57MW013 (upper)	1,1-Dichloroethene	74	Upgradient area
S57TW015 (lower)	Tetrachloroethene	7.1	Upgradient area
S57TW017 (lower)	Diethyl ether	4,800	Source area
S57TW018 (upper)	Trichloroethene	210	Source area
S57TW019 (lower)	Trichloroethene	62	Source area
S57MW022 (lower)	cis-1,2-Dichloroethene	1,400	Downgradient area
	Vinyl chloride	1,500	

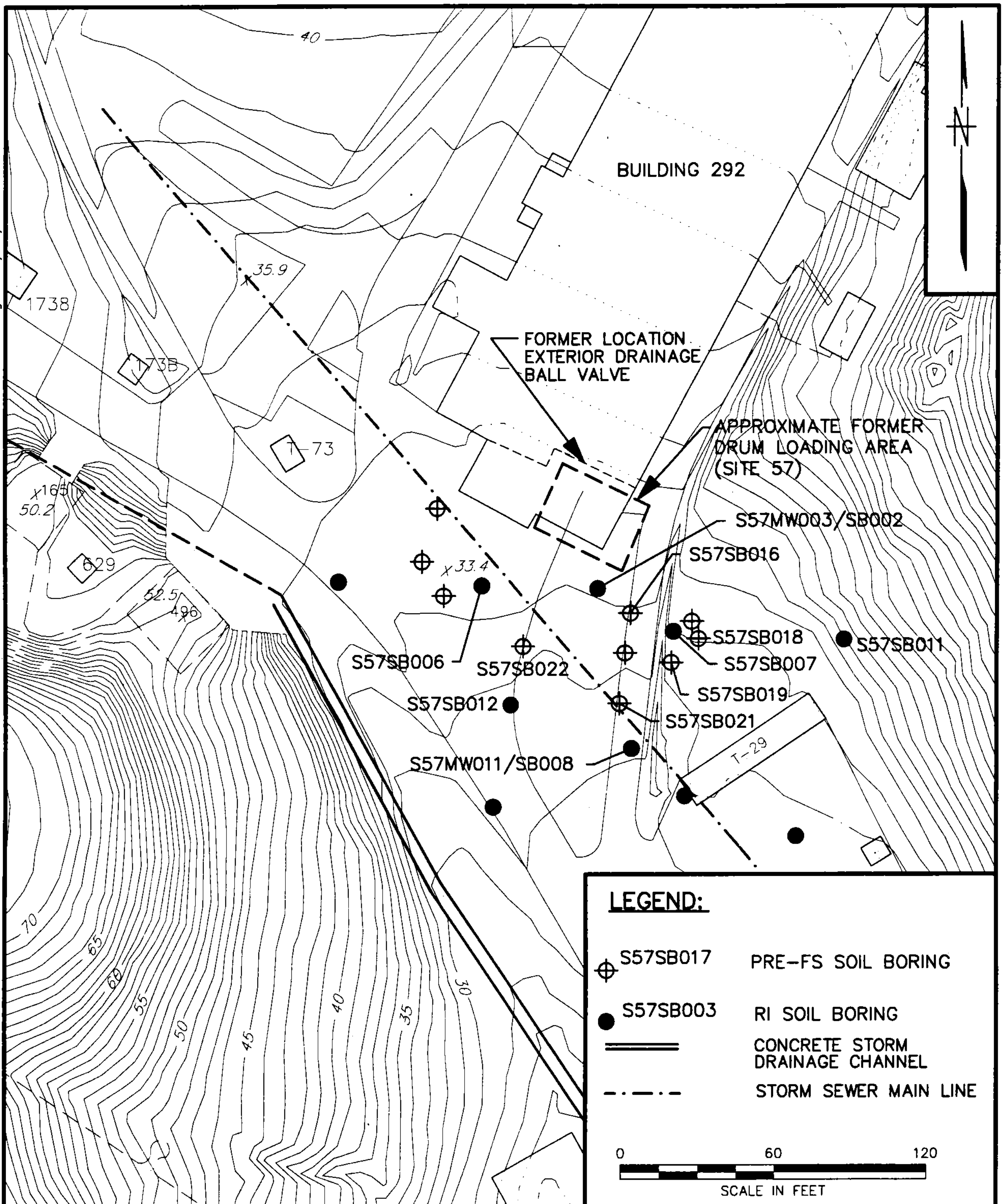
(1) Duplicate sample results. U = not detected.



ACAD: 4020CM04.dwg 04/29/02 HJB PIT

DRAWN BY / DATE	Tetra Tech NUS, Inc.	CONTRACT NO.	OWNER NO.
HJB 4/29/02		4020	
CHECKED BY / DATE: KCF 4/29/02	PRG EXCEEDANCE – SURFACE SOIL SITE 57–FORMER DRUM LOADING AREA INDIAN HEAD DIVISION NSWC INDIAN HEAD, MARYLAND	APPROVED BY: KCF	DATE: 4/29/02
COST/SCHED-AREA		APPROVED BY	DATE
SCALE: AS NOTED		DRAWING NO. FIGURE 2–1	REV. 0

FORM CADD NO. SOUTH_AV.DWG - REV 0 - 02/07/97



ACAD: 4020CM05.dwg 04/29/02 HJB PIT

DRAWN BY HJB DATE 4/29/02	Tetra Tech NUS, Inc.	CONTRACT NO. 4020	OWNER NO.
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COST/SCHED-AREA		APPROVED BY DATE	
SCALE AS NOTED		DRAWING NO. FIGURE 2–2	REV. 0

FORM CADD NO. SOUTH_AV.DWG – REV 0 – 02/07/97

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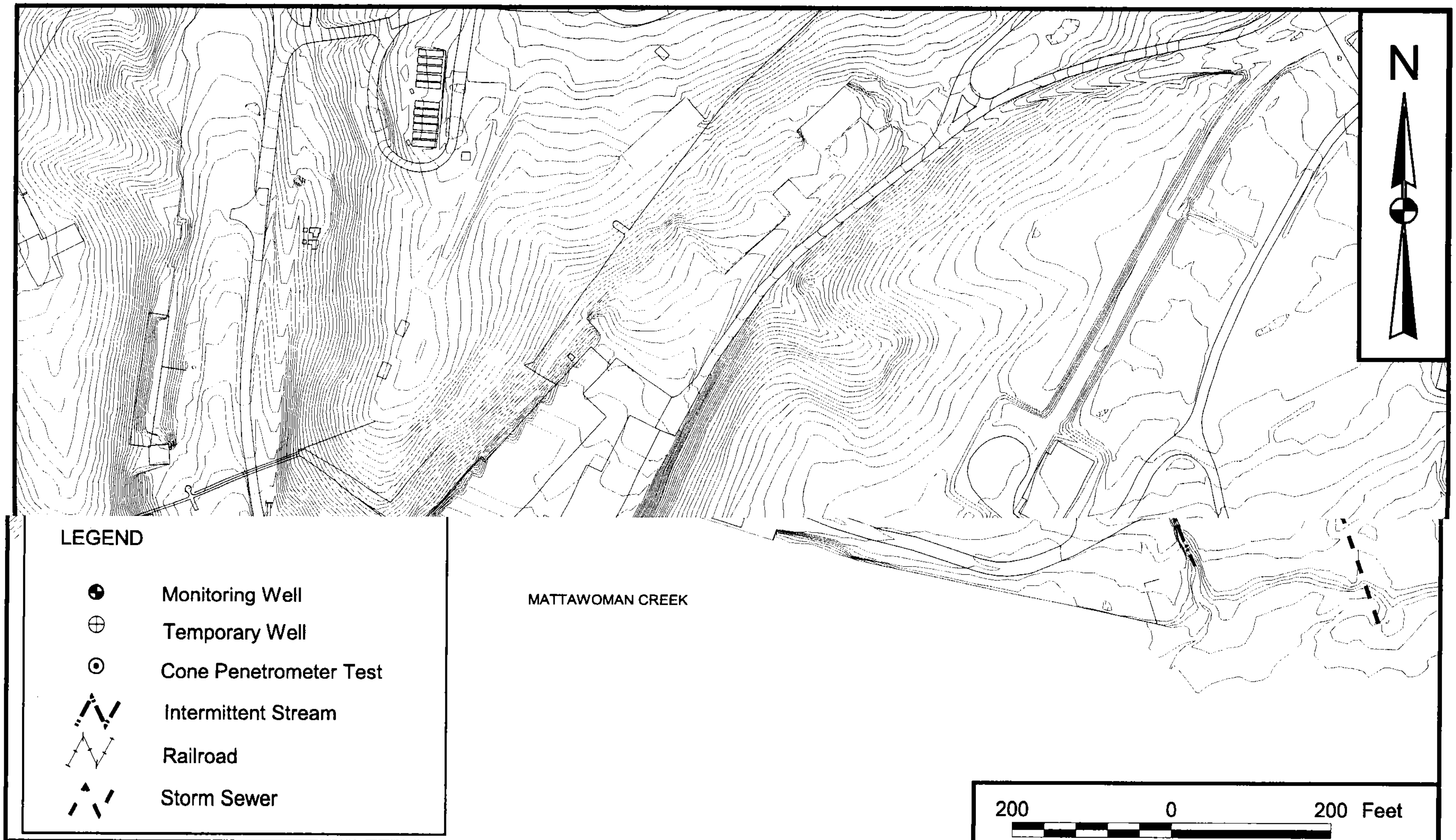

DRAWN BY K. PEILA	DATE 4/30/02	Tetra Tech NUS, Inc.	CONTRACT NUMBER 4020	OWNER NUMBER 805
CHECKED BY KCT	DATE 4/30/02	PRG EXCEEDANCE - GROUNDWATER SITE 57 - FORMER DRUM LOADING AREA IHDIV - NSWC INDIAN HEAD, MARYLAND	APPROVED BY KCT	DATE 4/30/02
COST/SCHEDULE-AREA			APPROVED BY	DATE
SCALE AS NOTED			DRAWING NO. FIGURE 2 - 3	REV 0

3.0 IDENTIFICATION AND SCREENING OF TECHNOLOGIES

This section categorizes, identifies, and evaluates technologies that can be applied to the remediation of Site 57.

3.1 INTRODUCTION

Identification, screening, and evaluation of potentially applicable technologies and process options are important steps in the FS process. The primary objective of this phase of the FS is to develop an appropriate range of remedial technologies and process options that can be combined into remedial alternatives. The basis for technology identification and screening began in Section 2.0 with a series of discussions, which included the following:

- Development of RAOs
- Identification of ARARs
- Development of PRGs
- Identification of COCs and media of concern
- Identification of volumes and areas of interest

Technology screening is completed and technology evaluation is performed in this section with the following steps:

- Identification of general response actions (GRAs)
- Identification and screening of remedial technologies and process options
- Evaluation of technologies and selection of representative process options

3.2 GENERAL RESPONSE ACTIONS

GRAs describe categories of actions that could be implemented to satisfy or address a component of a RAO for a site. Typically, the formation of remedial alternatives represents combining GRAs to fully address RAOs. When implemented, the combined GRAs are capable of achieving the RAOs that have been developed for each medium of interest at the site. As discussed in Section 2.0, the media of concern for Site 57 are soil and surficial aquifer groundwater.

The following GRAs are to be considered for Site 57:

- No action

- Institutional Actions
- Containment
- Removal
- Treatment
- Disposal

3.2.1 No Action

The no-action response is retained throughout the FS process as required by the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). The no-action response provides a comparative baseline against which other alternatives can be evaluated. Under this response, no remedial action is taken. The contaminated media are left as is without the implementation of any monitoring, land use controls, containment, removal, treatment, or other mitigating actions.

3.2.2 Institutional Actions

Institutional actions include various site access controls or land use restrictions to reduce or eliminate direct contact pathways of exposure. These controls could involve the use of monitoring, groundwater and land use restrictions, and access controls. The toxicity, mobility, and volume of the contaminants are not reduced through the implementation of land use controls.

3.2.3 Containment

Another method of reducing risk to human health and the environment is through containment that involves the use of physical measures to reduce the potential for exposure and the potential for contaminant migration. To reduce the migration of contaminants, the contaminated media must be isolated from the primary transport mechanisms such as wind, erosion, surface water, and groundwater. For example, installing surface or subsurface barriers or pumping groundwater from gradient control can be used to isolate contaminated media.

3.2.4 Removal

Technologies in this category are used to move a contaminated medium from its current location to be treated or disposed elsewhere. Removal process options are combined with treatment or disposal actions.

3.2.5 Treatment

This response action includes both in-situ and ex-situ treatment process and could include physical, chemical, biological, or thermal treatment techniques. Treatment processes are designed to reduce the toxicity, mobility, or volume of the contaminated medium. Ex-situ treatment processes are combined with removal and disposal actions to develop alternatives.

3.2.6 Disposal

Disposal actions include placement of removed and/or treated materials in an on-site or off-site permanent disposal facility. Disposal also includes on-site consolidation of contaminated materials and transfer of treated materials to another environmental medium (e.g., discharge of treated groundwater to surface water). Disposal actions are combined with removal or treatment actions. The toxicity, mobility, and volume of the contaminants are not reduced through the singular application of disposal.

3.3 IDENTIFICATION AND SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS

In this section, a variety of technologies and process options are identified under each GRA and screened. The screening is first conducted at a preliminary level to focus on relevant technologies and process options based on site conditions, medium of concern, and COCs. A more detailed evaluation is then conducted in Section 3.4, and process options are selected to represent technologies that have passed the detailed evaluation. The selected process options are combined to form remedial alternatives in Section 4.0. Some of the treatment technologies are based on presumptive remedies (preferred technologies) the EPA recommends for common categories of sites (e.g., VOCs in soil and groundwater, metals in soils). Other treatment processes are emerging technologies that have been identified by the Navy.

Table 3-1 summarizes the preliminary screening of technologies and process options for soil. Table 3-2 summarizes the preliminary screening of technologies and process options for groundwater. The tables list the GRA, identify the technologies and process options, and provide a brief description of the process options and screening comments. All technologies and process options that are not eliminated are evaluated in Section 3.4.

3.4 EVALUATION OF TECHNOLOGIES AND SELECTION OF REPRESENTATIVE PROCESS OPTIONS

3.4.1 Evaluation Criteria

The evaluation criteria for detailed screening of technologies and process options retained after the preliminary screening in Section 3.3 are effectiveness, implementability, and cost.

The effectiveness evaluation focuses on the following: potential effectiveness of process options in handling the estimated area or volumes of media and meeting the remediation goals identified in the RAOs, the potential impacts to human health and the environment during the construction and implementation phase, and how proven and reliable the process is with respect to the contaminants and conditions at the site.

Implementability encompasses both the technical and administrative feasibility of implementing a technology process. Technical implementability was used in the preliminary screening in Section 3.3 to eliminate those that are clearly ineffective or unworkable at the site. Therefore, this subsequent, more detailed evaluation places greater emphasis on the institutional aspects of implementability. This includes the ability to obtain necessary permits for off-site actions, the availability of treatment and disposal services, and the availability of necessary equipment and skilled workers to implement the technology.

Cost plays a limited role in the screening of process option. Relative capital and operation and maintenance (O&M) costs are used rather than detailed estimates. At this stage in the process, the cost analysis is made on engineering judgment, and each process is evaluated as to whether costs are high, low, or medium relative to other process options in the same technology type.

All the factors listed above may not directly apply to each process option and are only addressed as appropriate. Screening evaluations generally focus on effectiveness and implementability, with less emphasis on cost evaluations. Process options whose use would be precluded by waste characteristics and inapplicability to site conditions are screened and eliminated from further consideration. At this stage, no process options are eliminated based on cost. A process option within a technology category, however, may not be carried through to alternative development stage if an equally effective process option is available at a lower cost.

3.4.2 Evaluation of Technologies and Process Options for Soil

The final screening of technologies and process options is based on the evaluation criteria presented in Section 3.4.1. The following table presents the technologies and process options for soil remaining for final screening.

General Response Action	Remedial Technology	Process Options
No Action	None	Not applicable
Institutional Actions	Monitoring	Groundwater monitoring
	Access/use restrictions	Land use controls
Containment	Capping	Soil, asphalt, or multimedia cap
	Vertical barriers	Slurry wall, grout curtain, and sheet piling
Removal	Bulk excavation	Excavation
In-Situ Treatment	Physical/chemical	Soil vapor extraction
		Multi-phase extraction
Ex-Situ Treatment	Thermal	Low-temperature thermal desorption
Disposal	Landfill	Hazardous or nonhazardous waste landfill
	Backfill	Backfill

3.4.2.1 No Action

No action consists of implementing no activities to address contamination. No action is retained as required by the NCP; therefore, no evaluation is conducted.

3.4.2.2 Institutional Actions

The institutional actions that remain after preliminary are land use controls and monitoring. Records in the Base Master Plan (or deed restrictions) can be used to prevent future land use from posing a risk to human health. Monitoring may include the collection of groundwater samples, followed by analysis for target contaminants.

Effectiveness

Land use restrictions can be effective, depending on the administration of the controls. Sampling and analysis as part of a monitoring program are not effective in controlling risks to human health or the environment, but they can determine the effectiveness of a remedial action or the need for additional remedial action.

Implementability

Land use restrictions and monitoring are readily implementable, if the site will continue to be a federal facility.

Cost

Costs of land use restrictions are low. Costs associated with sampling and analysis are low to moderate, depending on the nature of the monitoring program.

Conclusion

Retain land use restrictions and groundwater monitoring.

3.4.2.3 Containment

The technologies being considered for containment include capping and vertical barriers.

Caps and covers can minimize the potential for human contact with surface soil. They can also reduce the migration of contaminants caused by surface water infiltration, runoff, and wind erosion. Soil covers consist of a layer of soil or clay placed or compacted over areas of soil contamination. Asphalt caps consist of a layer of asphalt placed over areas of soil contamination where vehicular access must be maintained. Multimedia caps (engineered caps) consist of layers of soil, synthetic materials, or composite materials placed or compacted over areas of soil contamination.

Vertical barriers consist of slurry walls, grout curtains, sheet piling, etc. that are used to minimize the horizontal migrations of contaminants, especially within the saturated zone. The barriers are placed around or downgradient of areas of contamination and extend from the ground surface to at least the bottom of the contamination and very commonly into a confining layer. The selection of the type of barrier depends on site-specific conditions, including compatibility of the barrier with subsurface conditions and contaminants.

Effectiveness

Soil covers, asphalt caps, and multimedia caps can be effective in minimizing human exposure to contaminated surface soil. The use of low-permeability materials, such as compacted clay, synthetic membranes, or composite materials, would be effective in minimizing rainfall infiltration into the contaminated material beneath the cover.

The use of vertical barriers may be considered if horizontal migration of subsurface soil (and groundwater) contaminants is a potential concern. Slurry walls are more commonly used than ground curtains and sheet piling and may be more effective in coarser soils.

Implementability

The main concern with the implementation of caps is the maintenance of the integrity of the cap from natural and human interferences. Another concern is installing covers and caps on steep slopes; however, in many cases, the area can be regraded to an acceptable slope. The area around Site 57 is an active facility with a roadway that is frequently used. The activities that are conducted (primarily vehicular traffic) there could damage a soil cover or cap unless contaminated areas were covered with pavement or concrete. In addition, the cap system would need to retain the existing topography and grades near Building 292.

The use of vertical barriers must consider the control of water-table levels within the contained area and could cause an increase in upgradient groundwater elevations. Maintenance of the integrity of vertical barriers is difficult over the long term.

Cost

Costs for soil covers and asphalt caps are low to moderate. Costs for engineered caps are moderate to high, depending on the materials and labor involved in placement. Costs of vertical barriers are moderate for slurry walls and sheet piling but high for grout curtains.

Conclusions

Retain the use of an asphalt cap underlain by a synthetic membrane as an effective means of minimizing exposure to human receptors and restricting infiltration. Most of the area where soil contaminants exceed PRGs are near Building 292, in a paved traffic area. This would not be suitable for installation of other types of covers and caps that would change the existing grade or could be damaged by traffic or any future intrusive activities. Therefore, other types of caps are eliminated from further consideration.

Eliminate the use of vertical barriers to reduce horizontal migration of soil contaminants. Soil contaminants below the water table would migrate with groundwater and would be more effectively addressed as part of remedial actions for groundwater.

3.4.2.4 Removal

Excavation can be performed by a variety of equipment, such as front-end loaders, backhoes, grade-alls, clamshells, and draglines. The type of equipment that is selected must consider several factors, such as the type of material, load-supporting ability of the soil, rate of excavation that is required, depth of excavation, and site access. The excavated location is usually backfilled with clean fill or treated soil, graded, and revegetated or otherwise restored.

Effectiveness

Excavation can be effective in the complete removal of contaminated material from a site. Confirmation sampling is usually required to verify that all contaminated material has been removed. Soil samples are collected from the sides and bottom of the excavation and analyzed for the contaminants of concern to ensure that the clean-up goals have been attained.

Implementability

The availability of excavation equipment is not a concern. The technology is well proven and established in the remediation industries. Excavation below the water table may require dewatering to lower the water table below the bottom of the depth of contamination. The water may need to be treated and disposed appropriately. Excavation would need to be conducted so it would minimize interference with current site activities.

Cost

Excavation costs are typically low, unless unusual conditions are encountered.

Conclusion

Retain excavation for further consideration. The potential implementability concerns can be overcome by coordinating remediation with current site activities.

3.4.2.5 In-Situ Treatment

The process options considered under in-situ treatment are soil vapor extraction (SVE) and multi-phase extraction (MPE).

SVE is a process that physically removes contaminants by inducing air flow by applying a vacuum to extraction wells screened in the saturated zone. VOCs tend to partition into air as the air moves through the soil to the extraction wells. The gas leaving the soil may be treated to recover or destroy the contaminants, depending on air discharge regulations. SVE is one of the presumptive remedies identified by EPA where VOCs are present in soil.

<u>MPE</u> is an enhancement of the SVE option under the presumptive remedy for sites with VOCs in soil. MPE simultaneously extracts both groundwater and soil vapor. The water table is lowered so that the SVE process can be applied to the newly exposed soil. This allows the VOCs sorbed on the previously saturated soil to be stripped by the induced airflow and extracted. In addition, soluble VOCs present in the extracted groundwater are also removed.

<u>Effectiveness</u>

SVE is a well-demonstrated technique for removing VOCs from the vadose zone (i.e., above the water table). It may not be as effective in soils with low-permeability soils. It is not effective for most PAHs or metals. A draft engineering evaluation/cost analysis (EE/CA) was prepared in 1996 to determine the most effective approach for addressing TCE contamination in soil at Site 57 (B&R Environmental, 1996). The EE/CA recommended SVE. Consequently, a pilot study was conducted at Site 57 to verify the suitability of the site for application of the SVE process. The pilot study demonstrated that the site is not suitable for SVE (B&R Environmental, 1997).

MPE has proven to be more effective at removing subsurface VOCs at low- to moderate-permeability sites than conventional pump-and-treat and SVE systems alone. It can remove contaminants from above and below the water table. It is not effective for metals.

<u>Implementability</u>

SVE is a readily available conventional process that has been used at numerous Superfund sites. Air pollution controls may be required. There may be operational problems if the air extraction wells are screened near the water table. The depth to the water table near Building 292 is approximately 8 feet.

MPE is an innovative process that has been applied at dozens of sites. Air pollution controls may be needed. The aquifer must be able to be dewatered for MPE to be successful. Although some transfer of VOCs from groundwater to the vapor phase is expected, extracted groundwater may need to be further treated prior to discharge. Air pollution controls may be required.

Treatability studies would be required for both of these treatment processes.

Cost

The cost of SVE is low. Costs for MPE would be higher because additional equipment would be needed. MPE costs also depend on the amount of extracted groundwater that would require treatment.

Conclusion

Eliminate SVE for removal of VOCs from vadose zone soil because of effectiveness concerns identified during the previous pilot study. Eliminate MPE because of effectiveness concerns for the SVE part of the MPE process.

3.4.2.6 Ex-Situ Treatment

The process option considered under ex-situ treatment is low-temperature thermal desorption.

Low-temperature thermal desorption is a physical separation process that treats wastes at 200 to 600°F to volatilize water and organic contaminants. A carrier gas or vacuum system transports volatilized water and organic contaminants to a gas treatment system. The bed temperatures and residence times will volatilize selected contaminants but typically will not oxidize or destroy them. Two common thermal desorption designs are the rotary dryer and thermal screw. Rotary dryers are horizontal cylinders that can be indirect or direct fired. The dryer is normally inclined and rotated. For thermal screw units, screw conveyors or hollow augers are used to transport the medium through an enclosed trough. Hot oil or stream circulates through the auger to indirectly heat the medium.

Effectiveness

Thermal desorption should be effective at volatilizing the VOCs of concern. It is not effective for metals. Contaminant destruction efficiencies in the afterburners of these units are greater than 95 percent. The same equipment could probably meet stricter requirements with minor modifications, if necessary. Decontaminated soil could be used as backfill if PRGs are met or it can be transported to an off-site landfill.

Implementability

Low-temperature thermal desorption is an innovative process that is being used more often. Full-scale and mobile units are available. All thermal desorption systems require treatment of the off-gas to remove particulates and contaminants. Dewatering may be necessary to achieve acceptable soil moisture content. Heavy metals in the feed may produce a solid residue that requires further treatment or disposal. On-site thermal desorption would be preferred over off-site treatment because the soil could be used to backfill excavated areas, assuming that soil PRGs can be attained.

Costs

The relative cost of low-temperature thermal desorption is low to moderate. However, mobilization costs would be relatively high for small volumes of soil.

Conclusion

Low-temperature thermal desorption would be effective and implementable for removing VOCs; however, it is not effective for metals. The relatively small volume of contaminated soil would not justify mobilization of on-site treatment equipment. In addition, the treated soil would contain arsenic at concentrations above PRGs, which could preclude the soil's use as backfill in the excavation(s). Therefore, this process is eliminated from consideration.

3.4.2.7 Disposal

The process option considered under disposal is off-site hazardous or nonhazardous waste landfill.

Off-site disposal is applicable to excavated soil. Landfills differ mainly in the types of wastes that they are permitted to accept. Nonhazardous waste landfills are permitted to accept municipal solid waste, construction and demolition debris, contaminated soil, and other waste that must be proven to have nonhazardous characteristics. Hazardous waste landfills can accept listed and characteristic RCRA hazardous wastes. The soil at Site 57 was contaminated by a release of a listed RCRA hazardous waste (i.e., spent TCE). Soil with chemical concentrations higher than the LDR treatment standards would need to be treated (on site or off site) prior to disposal in a hazardous waste landfill. Soil with chemical concentrations lower than the LDR treatment standards would not need to be treated but would still need to be disposed in a hazardous waste landfill. Soil with chemical concentrations lower than risk-based values (PRGs for residential use) could be disposed at a nonhazardous waste landfill or used as on-site backfill.

Effectiveness

Landfilling can be an effective method for disposal of contaminated soils if the receiving facility is properly designed and operated.

Implementability

There are no major implementability concerns with off-site landfilling. Hazardous waste and nonhazardous waste landfills are available. Some hazardous waste landfill facilities also have capabilities to treat hazardous waste that does not attain LDR treatment standards.

Cost

The cost of disposal in nonhazardous waste landfills is low to moderate. The cost of disposal at hazardous waste landfills is high.

Conclusion

Off-site landfilling is retained for further consideration. The type of landfill would be dependent on the characteristics of the soil excavated from the site. The use of treated soil as backfill is not an option because no suitable ex-situ treatment processes for soil passes the technology and process option screening.

3.4.3 Evaluation of Technologies and Process Options for Groundwater

The final screening of technologies and process options is based on the evaluation criteria presented in Section 3.4.1. The following table presents the technologies and process options for groundwater that remain for final screening.

General Response Action	Remedial Technology	Process Option
No Action	None	Not applicable
Institutional Actions	Monitoring	Groundwater monitoring
	Access/use restrictions	Groundwater use restrictions
Containment	Vertical barriers	Slurry wall, grout curtain, and sheet piling
		Hydraulic barrier
Removal	Groundwater extraction	Extraction wells
		Collection trench
In-Situ Treatment	Physical/biological	Air sparging/soil vapor extraction
	Physical/chemical	Multi-phase extraction
		Permeable reactive barriers
		Chemical oxidation
	Natural attenuation	Monitored natural attenuation
	Biological	Enhanced biodegradation

General Response Action	Remedial Technology	Process Option
Ex-Situ Treatment	Physical/chemical	Air stripping
		Adsorption
		Chemical oxidation
Discharge/Disposal	Surface discharge	Direct discharge
	Subsurface discharge	Reinjection

3.4.3.1 No Action

No action consists of implementing no activities to address contaminated groundwater. No action is retained as required by the NCP; therefore, no evaluation is conducted.

3.4.3.2 Institutional Actions

Institutional actions remaining after preliminary screening consist of groundwater use restrictions and monitoring. Records in the Base Master Plan (or deed restrictions) can be used to prevent future groundwater use from posing a risk to human health. Monitoring may include the collection of groundwater samples followed by analysis to target contaminants.

Effectiveness

Groundwater use restrictions can be effective, depending on the administration of the controls. Sampling and analysis are not effective in controlling risks to human health or the environment, but they can be used to determine the effectiveness of a remedial action or the need for additional remedial action.

Implementability

Groundwater use restrictions and monitoring are readily implementable if the site will continue to be a federal facility.

Cost

Costs of groundwater use restrictions are low. Costs associated with sampling and analysis are low to moderate depending on the nature of the monitoring program.

Conclusion

Retain groundwater use restrictions and groundwater monitoring.

3.4.3.3 Containment

The technologies being considered for containment are vertical barriers and hydraulic barriers. Containment of groundwater can be performed using hydraulic controls, such as extraction wells and collection trenches, or passive controls, such as vertical barriers. Extraction wells, collection trenches, and vertical barriers can be used to contain a contaminant plume by restricting lateral migration of the groundwater. Passive barriers are evaluated in this section. Hydraulic barrier process options are discussed in Section 3.4.3.4.

Vertical barriers include slurry walls, grout curtains, and sheet piles that are used to minimize the horizontal migration of contaminants, especially in the saturated zone. These barriers are placed around wastes or contaminated areas. Vertical barriers extend from the ground surface to at least the bottom depth of the contamination or to the confining layer of the aquifer. The type of barrier that is selected depends on site-specific conditions.

Effectiveness

The use of vertical barriers may be considered if horizontal migration of contaminants from groundwater (or contaminated soil) is a concern. Slurry walls are more commonly used than grout curtains and sheet piling and may be more effective in controlling contaminant migration in coarser soils. If the barrier cannot be installed into a confining layer, it may be less effective.

Implementability

The use of vertical barriers must consider the control of water-table levels within the contained area and could cause an increase in upgradient groundwater elevations. This is less concern if the barrier is not installed into a confining layer where groundwater can flow beneath the barrier. Maintenance of the integrity of vertical barriers is difficult over the long term, and groundwater monitoring may be required to ensure the barrier remains effective. An excessive depth to the confining layer may cause problems with constructability. The depth to the confining layer at Site 57is not excessive and is approximately 35 feet near Building 292 and decreases with downgradient distance.

Cost

The costs for vertical barriers are moderate for slurry walls and sheet piling and high for grout curtains.

Conclusion

Eliminate the use of vertical barriers (slurry walls) to minimize the horizontal migration of groundwater and contaminants in the saturated zone. Control of groundwater migration at this site would be more effective using extraction wells to create a hydraulic barrier (see Section 3.4.3.4).

3.4.3.4 Removal

Remediation and containment of groundwater may be achieved by removal of contaminated groundwater from the aquifer. The process options for groundwater removal that are evaluated in this section are extraction wells and collection trenches.

Extraction wells are used to contain or remove a contaminated groundwater plume or to adjust groundwater levels to prevent formation of a plume. The selection of the appropriate well system depends on the depth of contamination and the hydrogeologic and geologic characteristics of the aquifer. Well systems are very versatile and can be used to contain, remove, divert, or prevent development of plumes under a variety of site conditions. Extraction of the groundwater can also be used to lower the water table so contaminated saturated soil can be excavated.

Collection trenches are used to collect and convey groundwater by gravity flow. They function like a continuous line of extraction wells. A collection trench is formed by excavating to the desired depth. Collection pipes, pumps, and filter fabric are placed in the trench to allow for water removal. The trench is then backfilled with permeable material, such as gravel or crushed rock. Collection trenches can be used to contain or remove groundwater or to prevent contact of water with a contaminated material. They offer the advantage of collecting groundwater in situations where the groundwater recharge rate is insufficient to sustain extraction well pumping. They are, however, less effective at lowering the water table.

Effectiveness

Groundwater pumping systems are the most versatile and flexible of the groundwater control techniques. They are effective under a variety of geologic and hydrogeologic conditions, including those found at Site 57. Extraction of contaminated groundwater through appropriately located wells would reduce the contaminant concentrations in the subsurface. Extracted groundwater would then require treatment and disposal.

The effectiveness of collection trenches depends on the depth. Collection trenches are used for relatively shallow aquifers. They are most effective for aquifers that have low hydraulic conductivities and shallow gradients. Limitations include the presence of viscous or reactive chemicals that could clog the filter fabric and drains. Such chemicals were not detected in Site 57 groundwater. Conditions that favor the formation of iron, manganese, and calcium carbonate deposits may also limit the use of trenches. Although these limitations also apply to extraction wells, the adverse effects are more pronounced and less easily repaired for collection trenches.

Implementability

Installation of a groundwater pumping system is technically feasible. Contractors qualified to drill and install wells are readily available. Pumps, casings, and screens must be maintained to ensure a constant, reliable flow of water from the well. Well maintenance is especially important in plume management because the loss of a well could result in the migration of contaminants. The causes of well yield loss and failure are typically encrustation of the well screen, corrosion, and pump failure.

Collection trenches are readily implementable for aquifers with a shallow confining layer, and equipment and resources are readily available. Collection trenches may be difficult to implement at Site 57 because of the presence of a shallow water table. This would require excessive excavation and construction below the water table to the depth of the confining layer (approximately 35 feet at Building 292).

Cost

Costs of well systems for plume management vary greatly from site to site and depend on site geology, groundwater characteristics, contaminant characteristics, extent of contamination, and period and duration of pumping. Typically, capital and O&M costs are moderate.

Costs of collection trenches depend on the depth of excavation, soil stability, and groundwater flow rates. Capital costs are generally moderate to high, and O&M costs are low.

Conclusion

Extraction wells are retained for further consideration. Collection trenches are removed from further consideration. The presence of a shallow water table and the depth to a confining layer (approximately 35 feet) make extraction wells the more effective and implementable process option for groundwater containment or removal.

3.4.3.5 In-Situ Treatment

The process options considered under in-situ treatment are air sparging/soil vapor extraction (AS/SVE), MPE, permeable reactive barriers, chemical oxidation, monitored natural attenuation, and enhanced biodegradation.

AS/SVE is a process in which pressurized air is injected into a contaminated aquifer. Air streams traverse horizontally and vertically through the soil column and remove contaminants by volatilization. The air carries the contaminants to a vapor extraction system that remove the generated vapor-phase contamination. In addition, the increased dissolved oxygen level in the aquifer would enhance aerobic biodegradation of the contaminants. Optimizing the air sparging flow rate to emphasize biodegradation in comparison to volatilization is sometimes called biosparging.

MPE provides air flow through the vadose zone to remediate VOCs by vapor extraction and/or bioventing. The air flow also extracts groundwater for treatment above ground. The screen in the extraction well is positioned in both the unsaturated and the saturated zones. A vacuum applied to the well using a drop tube near the water table extracts soil vapor. The vapor movement entrains groundwater and carries it up the tube to the surface. Once above grade, the extracted vapors and groundwater are separated and treated. The drop tube is located below the static water level so the water-table elevation is lowered, exposing more contaminated soil to remediation by the air flow. A variation of the system uses pumps to extract groundwater and lower the water table so that saturated zone soils can be treated by SVE.

Permeable reactive barriers (PRBs) consist of trenches placed in the path of a dissolved contaminant plume. The trench is filled with reactive material such as granular iron to dechlorinate halogenated organics, granular activated carbon to adsorb organics, or other treatment media. As the groundwater passes through the treatment barrier, the contaminants react with the media.

Chemical oxidation involves injecting chemical oxidants into groundwater to oxidize contaminants. Common oxidants are hydrogen-peroxide-based Fenton's reagent and potassium permanganate. Ozone can also oxidize organic contaminants in situ, but ozone is not commonly used. Fenton's reagent is produced on site by adding iron catalyst to a hydrogen peroxide solution.

Monitored natural attenuation refers to inherent processes that affect the rate of migration and the concentration of contaminants in groundwater. The most important processes are biodegradation, advection, hydrodynamic dispersion, dilution from recharge, sorption, and volatilization. Consideration of this option requires modeling and evaluation of contaminant degradation rates and pathways.

Enhanced biodegradation refers to the addition of nutrients and/or chemicals to enhance the natural biodegradation of organic compound.

Effectiveness

AS/SVE is used primarily to treat compounds with high vapor pressure and low solubility, such as halogenated and nonhalogenated VOCs. Subsurface heterogeneity can interfere with uniform air distribution. The process is less effective in low-permeability soil and aquifers. AS/SVE can simultaneously remove VOCs from soil in the vadose zone and from soil and groundwater in the saturated zone. As stated in Section 3.4.2.5, a previous pilot study concluded that the SVE portion of this process would not be effective at Site 57.

MPE has been proven to be more effective at removing subsurface VOCs at low- to moderate-permeability sites than conventional pump-and-treat and AS/SVE systems alone. Subsurface heterogeneity can interfere with collection of contaminated groundwater and aeration of contaminated soil. As previously stated in Section 3.4.2.5, the SVE portion of the MPE process may not be effective.

PRBs have mainly been used in the field to degrade chlorinated solvents using zero-valent granular iron. The mechanism of chlorinated solvent degradation with zero-valent iron has been the most widely studied and reported to date. Impermeable funnel wings or walls on either side of the treatment trench can be used to enhance the effectiveness by directing the plume toward the treatment area. The reactive material cell wall may have to be flushed or the reactive medium replaced periodically if precipitates build up to the point that reactivity or hydraulic performance is affected. This can potentially be overcome by incorporation of sufficient safety factors in the design.

In-situ chemical oxidation is most effective for sites contaminated with halogenated VOCs and dense non-aqueous phase liquid (DNAPL) in saturated soil and groundwater. The effectiveness for diethyl ether is not known. This emerging process can be applied to highly contaminated sites or source areas to reduce contaminant concentrations. It is not generally cost effective for large plumes with lower contaminant concentrations. The contaminant plume at Site 57 covers an area of more than 2.5 acres. Residual levels of potassium permanganate, which is purple, can result in discoloration of the groundwater. The reaction of Fenton's reagent with VOCs can generate heat. This could cause a violent exothermic reaction if not applied carefully. This reaction could also cause volatilization of VOCs and subsequent migration through preferential pathways, such as sewers, and could cause the VOCs to enter buildings and other confined spaces.

Monitored natural attenuation is effective if the rate of biodegradation, aided by sorption and dilution, is rapid enough to prevent significant contaminant migration by advection and dispersion. Natural attenuation has proven to be effective for chlorinated solvents and fuel-related compounds. The detection of degradation products of TCE and 1,1,1-trichloroethane downgradient of the source area is evidence that natural attenuation is occurring at Site 57. The effectiveness for diethyl ether is not known.

Enhanced biodegradation is effective in accelerating in-situ biodegradation rates and has been proven to be effective for chlorinated solvents. The effectiveness of this process for diethyl ether is not known.

Treatability studies or evaluations would be required to verify the effectiveness of all the in situ treatment processes.

Implementability

AS/SVE is a readily available technology. Air pollution controls may be required, depending on state and local air pollution control regulations.

MPE is an innovative technology but is constructed of readily available materials. Air pollution controls may be required depending on state and local air pollution control regulations. The extracted groundwater may require treatment prior to discharge.

The use of permeable reactive barriers is an innovative technology, but the barriers are constructed of readily available materials. Because there are no above-ground structures, the affected site can be put to productive use while it is being cleaned up. The soil excavated from the trench would need to be properly disposed based on the chemical concentrations.

In-situ chemical oxidation is an emerging process that is being refined and tested by the Navy. The equipment and chemicals that are required are readily available. Subsurface heterogeneity can cause non-uniform distribution of the oxidant.

Natural attenuation would be readily implementable. A monitoring program can be accomplished without any major implementability concerns.

Enhanced biodegradation would be readily implementable. However, subsurface heterogeneity can cause non-uniform distribution of the oxidant.

Treatability studies or evaluations would be required to verify the effectiveness of all the in situ treatment processes.

Cost

The costs of AS/SVE and MPE are low to moderate. The costs for permeable reactive barriers are proportional to the size of the treatment trench. The need for impermeable walls to direct the plume would add to the cost. The costs of in-situ chemical oxidation are expected to be higher than for AS/SVE and MPE and dependent on the amount of chemicals required. Chemical oxidation is generally not cost effective for residual contaminant concentrations. The costs of monitored natural attenuation would be expected to be lower than for AS/SVE and MPE. The costs are proportional to the monitoring program needed to confirm the effectiveness of natural attenuation. The costs of enhanced biodegradation are dependent on the amount of additives needed to stimulate biological activity.

Conclusion

Eliminate AS/SVE and MPE for treatment of VOCs because of effectiveness concerns with the SVE portion of these processes. Eliminate chemical oxidation because of effectiveness and cost concerns for large, low-concentration groundwater plumes. Retain PRBs, monitored natural attenuation, and enhanced biodegradation for treatment of VOCs in the saturated zone.

3.4.3.6 Ex-Situ Treatment

The process options considered under ex-situ treatment are air stripping, adsorption, and chemical oxidation.

Air stripping involves the mass transfer of volatile contaminants from water to air. For groundwater remediation, this process is typically conducted in a packed tower or low-profile aeration system. The typical packed tower air stripper includes a spray nozzle at the top of the tower to distribute contaminated water over the packing in the column, a fan to force air countercurrent to the water flow, and a sump at the bottom of the tower to collect treated water. Low-profile air strippers are available in horizontal tray or vertical box designs. Baffles are used to route contaminated water two or more times along the length of the tray or height of the box. Air sparged through the bottom of the tray or through a vent pipe in the bottom of the box passes up through the water to strip out volatile compounds. Off-gas treatment may be required to comply with air pollution control regulations.

Granular activated carbon (GAC) adsorption is the most common adsorption process for groundwater treatment. Liquid-phase GAC treatment is performed by pumping groundwater through one or more vessels containing activated carbon, which removes contaminants from the water by sorption until available active sites are occupied. Carbon is "activated" by being processed to create porous particles with a large internal surface area that attracts and adsorbs organic molecules. As the available surface sites become occupied, the contaminant concentration in the bed effluent increases. When the contaminant concentrations in the effluent exceed a specified action level, the carbon can be regenerated in place, removed and regenerated at an off-site facility, or removed for disposal.

Chemical oxidation uses chemical oxidizing agents (e.g., ozone, hydrogen peroxide) to destroy toxic organic chemicals. Ultraviolet light is often used in conjunction with the oxidizing agent to promote faster and more complete destruction of organic compounds. Complete oxidation decomposes hydrocarbons into carbon dioxide and water, although chlorinated organics may also yield chlorine ions. If oxidation is incomplete, toxic constituents may remain or toxic degradation products can be formed. Chemical oxidation is carried out in batch or continuous reactors. Oxidants are generally added to contaminated groundwater in a mixing tank prior to introduction into the reactor. Ultraviolet lamps, if used, are typically enclosed in quartz tubes submerged inside the reaction vessel. The tubes are subject to fouling or scaling from compounds such as iron oxide or calcium carbonate.

Effectiveness

Air stripping is a well-proven, reliable technology for the removal of VOCs detected in groundwater. Theoretically, removal efficiencies greater than 99 percent can be achieved. Since air stripping only removes the contaminants from the water and transfers them to the air, the air may need to be treated depending on contaminant concentrations, air flow rates, and applicable discharge standards. Types of off-gas treatment include thermal oxidation, catalytic oxidation, and carbon adsorption. The type of off-gas treatment is primarily a matter of economics and is dependent on the air volume, contaminant, and contaminant concentration.

GAC adsorption has a long history of use in treating municipal, industrial, and hazardous wastewaters. Liquid-phase GAC can be used to remove VOCs and other organic chemicals. Removal efficiencies greater than 99 percent can be achieved for some contaminants. Limited effectiveness may be achieved for some halogenated VOCs, such as vinyl chloride and dichloroethenes. These VOCs are weakly sorbed, causing low GAC capacity. Since GAC adsorption only concentrates the contaminants, the spent carbon would have to be regenerated or disposed.

Chemical oxidation is a proven and effective process for the removal of most, but not all, organics. It is generally more effective for alkenes than alkanes. The process is generally effective for concentrations less than 500 µg/L. Ultraviolet light can enhance the oxidation of compounds that are resistant to chemical oxidation alone. Destruction efficiencies of 99 percent or more may be expected for some organics.

Implementability

Air stripping is a conventional process that would be readily implementable at the site. A sufficient number of vendors provide air stripping equipment. If activated carbon is used to treat the off-gas, subsequent regeneration or disposal must be provided. One maintenance consideration for air stripping is channeling of the flow resulting from clogging of the packing material. Common causes of clogging are suspended solids, oxidized manganese, and oxidized iron.

GAC adsorption is a conventional process that would be readily implementable. There are a sufficient number of vendors providing this process. Implementation factors include planning for disposal or regeneration of the exhausted carbon. Pretreatment may be required prior to the adsorption process to prevent clogging and excessive pressure drop in the treatment unit.

Chemical oxidation should be implementable, and several vendors offer this process. Site-specific treatability studies are generally recommended for chemical oxidation systems. Pretreatment may be required to condition groundwater for effective oxidation. If ultraviolet lamps are used, the studies must evaluate the potential for fouling or scaling of the quartz tubes. If fouling occurs, oxidation rates are drastically reduced. The use of ozone as the oxidizing agent requires an on-site ozone generator and an ozone decomposition unit or other emission control device. The use of hydrogen peroxide requires storage tanks and special handling procedures to ensure operator safety.

Cost

Capital costs for air stripping are low and O&M costs are low to moderate, depending on the need for off-gas treatment. Capital costs for GAC adsorption are moderate and O&M costs are low to moderate and are dependent on the carbon usage rate. Capital costs for chemical oxidation are high, and O&M costs are moderate to high and depend on the chemical usage rate.

Conclusion

Air stripping is retained for further consideration because VOCs are the only contaminants of concern for groundwater. GAC adsorption is eliminated from further consideration because of potential effectiveness concerns for the some of the VOCs of concern (e.g., vinyl chloride and dichloroethenes). Although chemical oxidation may be effective and implementable, air stripping is equally or more effective for the narrow range of VOCs of concern present at the site, is more readily available, and is less expensive.

3.4.3.7 Discharge/Disposal

The process options considered under discharge/disposal are direct discharge to surface water and reinjection into the shallow aquifer.

Direct discharge to surface water would involve discharging treated groundwater to Mattawoman Creek through a new pipeline, to the existing storm sewer that discharges to Mattawoman Creek, or to the unnamed tributary that flows to Mattawoman.

Reinjection would involve pumping treated groundwater into the shallow aquifer from which it was extracted.

Effectiveness

The discharge of treated groundwater to Mattawoman Creek through a new pipeline, the existing sewer, or the unnamed tributary would be effective if groundwater is treated to the necessary levels. Compliance with discharge limits would achieve RAOs. The effluent limits for discharge to an intermittent stream (unnamed tributary) would be expected to be more stringent than for direct discharge to Mattawoman Creek.

The reinjection of treated groundwater into the shallow aquifer would be effective if groundwater is treated to the necessary levels (i.e., PRGs for groundwater). Reinjection can reduce the time required to remediate an aquifer using conventional pump-and-treat methods. The clean, reinjected groundwater is expected to leach additional contaminants from soil in the saturated zone. However, the source area of the groundwater contamination is limited to a relatively small area near Building 292.

Implementability

Discharge to Mattawoman Creek through a new pipeline or existing sewer is readily implementable. The existing IHDIV-NSWC Virginia Pollutant Discharge Elimination System (VPDES) permit would need to be modified, and MDE would need to establish appropriate discharge limits. Discharge to the unnamed tributary may not be implementable. According to state regulations (COMAR 26.08.02.05-1), discharges to intermittent streams are not permitted when feasible alternatives are available.

Reinjection is normally implementable and would require equipment and materials similar to extraction wells. The presence of multiple structures and underground utilities in the upgradient plume area could cause some implementability concerns.

Cost

Costs for discharge to the existing sewer and the unnamed tributary would be lower than for construction of a new pipeline from the site to Mattawoman Creek. Costs for reinjection would be higher because additional equipment (injection pumps) would be required.

Conclusion

Retain discharge to the existing sewer and discharge to a new pipeline. Discharge to the unnamed tributary and reinjection are eliminated from further consideration because of implementability issues.

3.4.4 Selection of Representative Process Options

Tables 3-3 and 3-4 summarize the retained technologies and representative process options for soil and groundwater, respectively. Representative process options are chosen from each technology to assemble an adequate variety of effective and implementable alternatives and evaluate the alternatives in sufficient detail to aid in the final selection process. The specific process options selected for the remedial action will be determined during the remedial design or during bid evaluation and selection of the remedial contractor.

TABLE 3-1

PRELIMINARY SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR SOIL
SITE 57 – FORMER DRUM LOADING AREA
IHDIV-NSWC, INDIAN HEAD, MARYLAND

General Response Action	Technology	Process Options	Description	Screening Comments
No Action	None	Not applicable	No activities conducted to address contamination.	Required by NCP. Retain for baseline comparison.
Institutional Actions	Monitoring	Groundwater monitoring	Periodic sampling and analysis.	Retain to assess migration of contamination and to evaluate remedial actions.
	Access/Use Restrictions	Physical barriers	Fencing, markers, and warning signs to restrict site access.	Eliminate because site area is currently in use and there are no unacceptable risks to current receptors.
		Land use controls	Administrative action to restrict future activities.	Retain to control unacceptable risks to potential future receptors.
Containment	Capping	Clay, synthetic membrane, asphalt, or multimedia cap	Low-permeability barriers to minimize exposure to contaminants and migration to groundwater.	Retain to minimize exposure to surface soil contamination and vertical contaminant migration to groundwater.
	Vertical Barriers	Slurry wall, grout curtain, and sheet piling	Low-permeability barriers to restrict horizontal migration of contaminants.	Retain to minimize horizontal of soil (and groundwater contaminants).
	Horizontal Barriers	Liners, grout injection	Low-permeability barriers to restrict vertical migration of subsurface soil contaminants.	Eliminate because a confining layer is already present beneath site and because of implementability concerns.
Removal	Bulk Excavation	Excavation	Use of common construction equipment to remove contaminated soil.	Retain to remove contaminated soil to eliminate exposure.
In-Situ Treatment	Physical/ Chemical	Soil vapor extraction	Use of vacuum and possibly air sparging to volatilize and remove contaminants from the vadose zone.	Retain for removal of VOCs from soil above the water table. Not effective for metals.

TABLE 3-1

PRELIMINARY SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR SOIL
SITE 57 – FORMER DRUM LOADING AREA
IHDIV-NSWC, INDIAN HEAD, MARYLAND

General Response Action	Technology	Process Options	Description	Screening Comments
In-Situ Treatment (cont.)	Physical/ Chemical (cont.)	Multi-phase extraction	Use of vacuum and pumping to volatilize and remove contaminants from above and below the water table.	Retain for concurrent removal of VOCs from soil groundwater. Not effective for arsenic.
		Solidification	Use of pozzolanic materials in the vadose zone to chemically fix inorganics and solidify the matrix to reduce leachability.	Eliminate because migration of arsenic to groundwater is not a concern.
	Biological	Aerobic/Anaerobic	Enhancement of biodegradation of organics in an aerobic (oxygen-rich) and/or anaerobic (oxygen-deficient) environment by adding nutrients and other chemicals.	Eliminate because it is unproven for TCE and ineffective for arsenic.
Ex-Situ Treatment	Thermal	Low-temperature thermal desorption	Use of low to moderate temperatures to volatilize contaminants.	Retain for removal of VOCs from soil. Not effective for metals.
		Incineration	Use of high temperature to destroy organic contaminants.	The concentrations of VOCs in soil do not warrant the high cost of incineration. Not effective for arsenic.
	Physical/ Chemical	Solidification	Use of pozzolanic materials in the vadose zone to chemically fix inorganics and solidify the matrix to reduce leachability.	Eliminate because migration of arsenic to groundwater is not a concern.
	Biological	Aerobic/Anaerobic	Enhancement of biodegradation of organics in an aerobic (oxygen-rich) and/or anaerobic (oxygen-deficient) environment by adding nutrients and other chemicals.	Eliminate because it is unproven for TCE and ineffective for arsenic.

TABLE 3-1

PRELIMINARY SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR SOIL
SITE 57 – FORMER DRUM LOADING AREA
IHDIV-NSWC, INDIAN HEAD, MARYLAND

General Response Action	Technology	Process Options	Description	Screening Comments
Disposal	Landfill	Hazardous or nonhazardous waste landfill	Disposal of excavated material at a permitted on-site or off-site landfill.	Retain off-site landfilling to permanently remove contaminated materials. Eliminate on-site landfilling because suitable area is not available.
		Backfill	Disposal of treated soil where it was excavated from.	Retain for soil that has been treated to attain PRGs.
		Consolidation	Excavation and placement in one location to minimize space and closure requirements.	Eliminate because there is insufficient available land area.

TABLE 3-2

PRELIMINARY SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR GROUNDWATER
SITE 57 – FORMER DRUM LOADING AREA
IHDIV-NSWC, INDIAN HEAD, MARYLAND

General Response Action	Technology	Process Options	Description	Screening Comment
No Action	None	Not applicable	No activities conducted to address contamination.	Required by NCP. Retain for baseline comparison.
Institutional Actions	Monitoring	Monitoring	Periodic sampling and analysis to track the spread of contamination.	Retain to assess migration of contaminants from site and evaluate remedial actions.
	Access/Use Restrictions	Physical barriers	Fencing, markers, and warning signs to restrict site access.	Eliminate. Not applicable to groundwater.
		Groundwater use restrictions	Administrative action used to restrict future site activities and use.	Retain to limit human exposure to contaminated groundwater.
Containment	Vertical Barriers	Slurry wall, grout curtain, and sheet piling	Low-permeability barriers to restrict horizontal migration of groundwater.	Retain to reduce migration of groundwater contaminants.
		Hydraulic barrier	Use of extraction wells or collection trenches to restrict horizontal migration of groundwater.	Retain to reduce migration of groundwater contaminants.
	Horizontal Barriers	Physical barrier	Injection of bottom sealing slurry beneath or into an aquifer to minimize vertical migration of groundwater.	Eliminate because a confining layer is already present beneath site and because of implementability concerns.
Removal	Groundwater Extraction	Extraction wells	Series of conventional pumping wells used to remove contaminated groundwater.	Retain to remove contaminated groundwater.
		Collection trench	Permeable trench used to intercept and collect contaminated groundwater.	Retain to remove contaminated groundwater.
In-Situ Treatment	Physical/ Biological	Air sparging/soil vapor extraction	Volatilization and enhancement of biodegradation by supply of air and extraction of volatile gases.	Retain to remove VOCs from groundwater and soil below the water table.

TABLE 3-2

PRELIMINARY SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR GROUNDWATER
SITE 57 – FORMER DRUM LOADING AREA
IHDIV-NSWC, INDIAN HEAD, MARYLAND

General Response Action	Technology	Process Options	Description	Screening Comment
In-Situ Treatment (cont.)	Physical/ Chemical	Multi-phase extraction	Use of vacuum and pumping to volatilize and remove contaminants from above and below the water table.	Retain for removal of VOCs from soil above and below the water table and groundwater.
		Permeable reactive barriers	Passive in-situ treatment zone of reactive material that degrades or immobilizes contaminants as groundwater flows through it.	Retain to remove VOCs from groundwater.
		Lasagna™ process	Uses electric current to move contaminants in soil pore water (i.e., below the water table) into treatment zones where contaminants can be captured or decomposed.	Eliminate because this process is experimental and has only been used on relatively small areas.
		Chemical oxidation	Involves injecting chemical oxidants into groundwater to oxidize contaminants.	Retain to remove VOCs from groundwater.
	Natural Attenuation	Monitored natural attenuation	Use of natural processes that affect the rate of migration and the concentration of contaminants in groundwater.	Retain to treat contaminated groundwater.
	Biological	Enhanced biodegradation	Addition of chemicals and/or nutrients to enhance biodegradation of VOCs such as TCE.	Retain to treat contaminated groundwater.
Ex-Situ Treatment	Physical/ Chemical	Solid dewatering	Mechanical removal of free water from wastes using equipment such as a filter press or vacuum filter.	Not applicable. Removal of VOCs would not generate solids.

TABLE 3-2

PRELIMINARY SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR GROUNDWATER
SITE 57 – FORMER DRUM LOADING AREA
IHDIV-NSWC, INDIAN HEAD, MARYLAND

General Response Action	Technology	Process Options	Description	Screening Comment
Ex-Situ Treatment (cont.)	Physical/ Chemical (cont.)	Filtration	Separation of suspended solids from water via entrapment in a bed of granular material or membrane.	Not applicable. Removal of VOCs would not generate suspended solids. May be needed as a pretreatment step for VOC removal processes if high suspended solids are present.
		Reverse osmosis	Use of high pressure and membranes to separate dissolved metals from water.	Not applicable. Metals are not COCs for groundwater.
		Air stripping	Contact of water with air to removal volatile organics.	Retain to remove VOCs from extracted groundwater.
		Adsorption	Separation of dissolved contaminants via adsorption onto activated carbon, resins, or activated alumina.	Retain to remove VOCs from extracted groundwater.
		Extraction	Separation of contaminants from a solution by contact with an immiscible liquid with a higher affinity for the COCs.	Eliminate extraction because it is not applicable for low concentrations of contaminants.
		Distillation	Vaporization of liquid followed by condensation of the vapors to concentrate various constituents.	Eliminate distillation because it is not applicable for low concentrations of contaminants.

PRELIMINARY SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR GROUNDWATER
SITE 57 – FORMER DRUM LOADING AREA
IHDIV-NSWC, INDIAN HEAD, MARYLAND

General Response Action	Technology	Process Options	Description	Screening Comment
Ex-Situ Treatment (cont.)	Physical/ Chemical (cont.)	Sedimentation	Separation of solids from water via gravity settling.	Not applicable. Metals are not COCs for groundwater. Treatment of VOCs would not generate solids. May be needed as a pretreatment step for VOC removal processes if high suspended solids are present.
		Ion exchange	Process in which ions on a resin surface are exchanged for ions of similar charge.	Not applicable. Metals are not COCs for groundwater.
		Chemical oxidation	Use of oxidizers such as air, ozone, peroxide, chlorine, or permanganate to chemically increase the oxidation state of organic and inorganic compounds.	Retain for removal of organic contaminants.
		Reduction	Use of reducers such as sulfur dioxide, sulfite compounds, or ferrous iron compounds to decrease the oxidation state of organic and inorganic compounds.	Eliminate because it is not applicable to the COCs found in site groundwater.
		Chemical precipitation	Use of reagents to convert soluble constituents into insoluble constituents.	Eliminate because it is not applicable to the COCs found in site groundwater.
		Coagulation/ flocculation	Use of chemicals to neutralize surface charges and promote attraction of colloidal particles to facilitate settling.	Eliminate because it is not applicable to the COCs found in site groundwater.
		Neutralization/pH adjustment	Use of acids and bases to counteract excess pH.	Eliminate because it is not applicable to the COCs found in site groundwater.

TABLE 3-2

PRELIMINARY SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR GROUNDWATER
SITE 57 – FORMER DRUM LOADING AREA
IHDIV-NSWC, INDIAN HEAD, MARYLAND

General Response Action	Technology	Process Options	Description	Screening Comment
Discharge/ Disposal	Surface Discharge	Direct discharge	Discharge to surface water.	Retain for discharge of treated groundwater.
		Indirect discharge	Discharge to an existing sewage or industrial wastewater treatment plant.	Eliminate because no on-site facility available.
		Off-site treatment facility	Treatment and disposal at an off-site treatment facility.	Eliminate because expected volumes are too large for off-site transport.
	Subsurface Discharge	Reinjection	Use of injection wells, spray irrigation, or infiltration to discharge treated groundwater underground.	Retain for discharge of treated groundwater.

TABLE 3-3

SUMMARY OF RETAINED TECHNOLOGIES AND PROCESS OPTIONS FOR SOIL
SITE 57 – FORMER DRUM LOADING AREA
IHDIV-NSWC, INDIAN HEAD, MARYLAND

General Response Action	Technology	Process Options
No Action	None	Not applicable
Institutional Actions	Monitoring	Groundwater monitoring
	Access/use restrictions	Land use controls
Containment	Capping	Asphalt/geomembrane cap
Removal	Bulk excavation	Excavation
Disposal	Landfill	Off-site hazardous and nonhazardous waste landfill

TABLE 3-4

SUMMARY OF RETAINED TECHNOLOGIES AND PROCESS OPTIONS FOR GROUNDWATER
SITE 57 – FORMER DRUM LOADING AREA
IHDIV-NSWC, INDIAN HEAD, MARYLAND

General Response Action	Remedial Technology	Representative Process Option
No Action	None	Not applicable
Institutional Actions	Monitoring	Groundwater monitoring
	Access/use restrictions	Groundwater use restrictions
Containment	Vertical barriers	Hydraulic barrier
Removal	Groundwater extraction	Extraction wells
In-Situ Treatment	Physical/chemical	Permeable reactive barriers
	Natural attenuation	Monitored natural attenuation
	Biological	Enhanced biodegradation
Ex-Situ Treatment	Physical/chemical	Air stripping
Discharge/Disposal	Surface discharge	Direct discharge

4.0 DEVELOPMENT AND SCREENING OF ALTERNATIVES

4.1 INTRODUCTION

This section presents the rationale for and the development of the remedial alternatives that are evaluated in the FS. These alternatives are developed from the combinations of technologies and process options evaluated in Section 3.0.

4.2 RATIONALE FOR ALTERNATIVE DEVELOPMENT

The purpose of the FS is to evaluate the information provided in the RI and subsequent investigations that assess site conditions and develop an appropriate range of alternatives to allow remedy selection. The development of alternatives should reflect the scope and complexity of the site problems that are being addressed. The number and types of alternatives should also be based on the site characteristics and the complexity of the site concerns. Development of alternatives for Site 57 is based on the following:

- Technologies and process options remaining after the screening evaluations in Section 3.0
- Reasonably anticipated land use scenarios
- Exposure scenarios
- RAOs
- ARARs

4.2.1 Technologies and Process Options

General response actions and representative process options have been developed for the vadose zone soil and shallow groundwater at Site 57. Process options for groundwater also address saturated zone soil. Those general response actions and process options that have been retained for assembly into alternatives are as follows:

General Response Action	Process Options
No Action	Not applicable (soil and groundwater)
Institutional Actions	Groundwater monitoring (soil and groundwater) Land use controls (soil) Groundwater use restrictions (groundwater)

General Response Action	Process Options
Containment	Asphalt/synthetic geomembrane cap (soil) Hydraulic barrier (groundwater)
Removal	Excavation (soil)
Removal (cont.)	Extraction wells (groundwater)
In-Situ Treatment	Monitored natural attenuation (groundwater) Enhanced bioremediation (groundwater)
Ex-Situ Treatment	Air stripping (groundwater)
Disposal	Off-site hazardous waste or nonhazardous waste landfill (soil) Direct discharge (groundwater)

These process options will be used individually or in combination, as appropriate, to form remedial alternatives for soil and remedial alternatives for groundwater.

4.2.2 Land Use Scenarios

Potential exposure to environmental media is evaluated in the context of current land use and future land use. Under current land use, Site 57 and operations at Building 292 are used to actively fulfill the IHDIV-NSWC mission. Under future land use, Site 57 could be released to the public or remain under the control of the Navy. While under the control of the Navy, land use is expected to continue as is.

4.2.3 Exposure Scenarios

Assumptions for the land use scenarios and receptors used for alternative development are consistent with the Site 57 risk assessment.

Under the current land use scenario, Site 57 is assumed to remain as it currently exists. Existing current land use at and near the site is such that human receptors most likely to be exposed to contaminants at the site and migrating from the site are full-time employees. No adverse health effects are expected for full-time employees. In addition, there are no unacceptable risks to ecological receptors.

Under the potential future land use scenarios, potential receptors include construction workers and on-site residents. Possible adverse health effects could be expected for future construction workers exposed to a small area of surface soil contamination. Possible adverse effects could be expected for hypothetical future child and adult residents exposed to soil and groundwater. Potential risks to ecological receptors would not be expected.

4.2.4 Accommodation of Clean-up Goals and ARARs

In general, it is desirable to develop remedial alternatives that achieve compliance with all clean-up goals and ARARs. Soil contaminants are present at concentrations above clean-up goals based on protection of groundwater. Groundwater contaminants are present at concentrations that exceed ARARs (i.e., MCLs) and risk-based levels.

4.3 REMEDIAL ALTERNATIVE DEVELOPMENT FOR SOIL

This section develops the remedial alternatives for soil considering the information provided in Section 4.2. The following alternatives have been developed for soil at Site 57.

- Alternative 1 – No Action
- Alternative 2 – Capping with Land Use Controls
- Alternative 3 – Excavation and Off-Site Disposal

4.3.1 Soil Alternative 1 – No Action

No action is required for Alternative 1. This alternative is required by the NCP and is used as a baseline for comparison with other alternatives.

4.3.2 Soil Alternative 2 – Capping with Land Use Controls

Under Alternative 2, an asphalt and synthetic geomembrane cap would be installed over the area near Building 292 where VOC concentrations in soil exceed PRGs based on protection of groundwater. The cap would also cover most areas where arsenic concentrations exceed PRGs based on industrial and residential exposure. The cap would not cover the area near location S57SB005 where arsenic concentrations exceed the PRG based on residential exposure. Arsenic does not exceed PRGs based on protection of groundwater.

Land use controls would consist of maintaining records of the soil contamination at Site 57 in the Base Master Plan and designating the area as a restricted-use area. The area would be given a designation in the Base Master Plan that would prohibit residential or unauthorized intrusive (e.g., excavation) activities.

The information in the Base Master Plan would ensure that the Navy would be able to take adequate measures to minimize adverse human health effects at the time of any future land development or construction activities.

Monitoring would include periodic sampling of groundwater and analysis for the soil COCs (i.e., TCL VOCs). The objective of monitoring would be to confirm that no contaminants are migrating from soil to groundwater and to determine the effectiveness of the remedy.

At least every 5 years, a site review would be conducted to evaluate the analytical results from monitoring samples, evaluate the site status (i.e., the site's use at that time and plans for future use), review environmental laws and regulations in effect at the time of the review, and provide direction for further action, if deemed necessary. Site reviews are required because this alternative would allow contaminants to remain above levels that allow for unlimited use and unrestricted exposure. The site would also be subjected to the requirements of a Land Use Control Implementation Plan (LUCIP) currently under development, as well as a Land Use Control Action Plan (LUCAP) and a Long-Term Monitoring (LTM) Plan to be developed for Site 57.

4.3.3 Alternative 3 – Excavation and Off-Site Disposal

Under Alternative 3, all soil in which VOC concentrations exceed PRGs for protection of groundwater and where arsenic concentrations exceed PRGs based on residential exposure would be excavated and transported off site for disposal. Excavated areas would be backfilled with suitable material and restored to their original condition (e.g., paved or revegetated).

Monitoring, land use controls, and 5-year reviews would not be required because all contaminated soil would be removed from the site.

4.4 REMEDIAL ALTERNATIVE DEVELOPMENT FOR GROUNDWATER

This section develops the remedial alternatives for groundwater considering the information provided in Section 4.2. The following alternatives have been developed for groundwater at Site 57.

- Alternative 1 – No Action
- Alternative 2 – Monitored Natural Attenuation
- Alternative 3 – In-Situ Bioremediation
- Alternative 4 – Permeable Reactive Barrier
- Alternative 5 – Extraction and Treatment

4.4.1 Groundwater Alternative 1 – No Action

No action is required for Alternative 1. This alternative is required by the NCP and is used as a baseline for comparison with other alternatives.

4.4.2 Groundwater Alternative 2 – Monitored Natural Attenuation

Under Alternative 2, groundwater contamination would be allowed to naturally attenuate. Natural attenuation refers to inherent processes that affect the rate of migration and the concentration of contaminants in groundwater. The most important processes are biodegradation, advection, hydrodynamic dispersion, dilution from recharge, sorption, and volatilization. A screening evaluation for natural attenuation was conducted as part of this FS (Appendix G-1). The evaluation concluded that, with the exception of one downgradient location (S57MW022), conditions in the Site 57 groundwater are not favorable to the natural attenuation of chlorinated VOCs. However, the presence of TCE degradation products (e.g., dichloroethenes and vinyl chloride) indicates that some biodegradation is occurring.

Groundwater use restrictions would be implemented to ensure that contaminated groundwater is not used as a source of drinking water until the COC concentrations attain the PRGs. The groundwater use restrictions would consist of maintaining records of the groundwater contamination in the Base Master Plan and designating the area as a restricted-use area. The area would be given a designation in the Base Master Plan that would prohibit groundwater use. The information in the Base Master Plan would ensure that the Navy would be able to take adequate measures to minimize adverse human health effects at the time of any future land development.

Monitoring would include periodic sampling and analysis of groundwater. The objectives of the monitoring would be to determine the effectiveness of natural attenuation and confirm that contaminants are not migrating off site at unacceptable levels.

At least every 5 years, a site review would be conducted to evaluate the analytical results from monitoring samples, evaluate the site status (i.e., the site's use at that time and plans for future use), review environmental laws and regulations in effect at the time of the review, and provide direction for further action, if deemed necessary. Site reviews are required because this alternative would allow contaminants to remain above levels that allow for unlimited use and unrestricted exposure. The site would also be subjected to the requirements of a LUCIP currently under development, as well as a LUCAP and LTM Plan to be developed for Site 57.

4.4.3 Groundwater Alternative 3 – In-Situ Bioremediation

Under Alternative 3, an electron donor chemical (e.g., Hydrogen Release Compound, or HRC) would be injected into the TCE plume to accelerate in-situ biodegradation rates. HRC would be metabolized by naturally occurring microorganisms, resulting in the creation of anaerobic conditions and the production of hydrogen. Naturally occurring microorganisms capable of reductive chlorination then use the hydrogen to progressively remove chlorine atoms, thereby converting TCE to dichloroethene and vinyl chloride to ethene. An electron acceptor chemical (e.g., Oxygen Release Compound, or ORC) would be injected into the area near well S57MW022 that is contaminated with cis-1,2-dichloroethene and vinyl chloride. ORC is used to provide oxygen. The release of dissolved oxygen supports a number of biological oxidation pathways that result in the complete breakdown of the contaminants.

A screening evaluation for evaluating the potential applicability of reductive anaerobic in-situ bioremediation was conducted as part of this FS (Appendix G-2). The evaluation concluded that conditions at some well locations were favorable, and conditions at a few wells were unfavorable. However, it would be worthwhile to conduct further evaluations. The presence of TCE degradation products (e.g., dichloroethenes and vinyl chloride) indicates that some biodegradation is occurring that could possibly be enhanced.

Groundwater use restrictions would be implemented to ensure that contaminated groundwater is not used as a source of drinking water until groundwater PRGs are attained. The groundwater use restrictions would consist of maintaining records of the groundwater contamination in the Base Master Plan and designating the area as a restricted or limited-use area. The information in the Base Master Plan would ensure that the Navy would be able to take adequate measures to minimize adverse human health effects at the time of any future land development.

Monitoring would include periodic sampling and analysis of groundwater. The objectives of the monitoring would be to determine the effectiveness of bioremediation and confirm that contaminants are not migrating off site at unacceptable concentrations.

A 5-year site review may be conducted to evaluate the analytical results from monitoring samples, evaluate the site status (i.e., the site's use at that time and plans for future use), review environmental laws and regulations in effect at the time of the review, and provide direction for further action, if deemed necessary. Site reviews are required because this alternative would allow contaminants to remain above levels that allow for unlimited use and unrestricted exposure. This review would not be required if PRGs were attained in less than 5 years. The site would also be subjected to the requirements of a LUCIP currently under development, as well as a LUCAP and LTM Plan to be developed for Site 57.

4.4.4 Groundwater Alternative 4 – Permeable Reactive Barrier

Under Alternative 4, a permeable reactive barrier (PRB) would be installed at the downgradient portion of the TCE plume. The PRB would consist of a zone of reactive material installed in the path of the TCE plume. The most commonly used media are zero-valent metals, particularly granular iron. As the groundwater flows through the reactive zone, the COCs come in contact with the reactive medium and are degraded to potentially nontoxic dehalogenated organic compounds and inorganic chloride. As the zero-valent metal in the reactive cell corrodes, the resulting electron activity reduces the chlorinated compounds. PRBs typically may be installed as a continuous reactive barrier or as a funnel-and-gate system. A continuous reactive barrier consists of a reactive cell containing the reactive medium. A funnel-and-gate system has an impermeable section (or funnel) that directs the captured groundwater toward the permeable section (or gate). The use of PRBs is an emerging technology that has shown to be effective for removal of chlorinated VOCs from groundwater; however, there are few long-term operational or performance data available.

Groundwater contaminated with cis-1,2-dichloroethene and vinyl chloride near well S57MW022 would be allowed to naturally attenuate, as described in Section 4.4.2 for Alternative 2.

Groundwater use restrictions would be implemented to ensure that contaminated groundwater is not used as a source of drinking water until the COC concentrations attain PRGs. The groundwater use restrictions would consist of maintaining records of the groundwater contamination in the Base Master Plan and designating the area as a restricted-use area. The area would be given a designation in the Base Master Plan that would prohibit groundwater use or unauthorized activities that could damage the PRB. The information in the Base Master Plan would ensure that the Navy would be able to take adequate measures to minimize adverse human health effects at the time of any future land development.

Monitoring would include periodic sampling and analysis of groundwater. The objectives of the monitoring would be to determine the effectiveness of the PRB; confirm that contaminants are not migrating off site at unacceptable levels, and to ensure that the contaminants near well S57MW002 are naturally attenuating.

At least every 5 years, a site review would be conducted to evaluate the analytical results from monitoring samples, evaluate the site status (i.e., the site's use at that time and plans for future use), review environmental laws and regulations in effect at the time of the review, and provide direction for further action, if deemed necessary. Site reviews are required because this alternative would allow contaminants to remain above levels that allow for unlimited use and unrestricted exposure. The site would be subjected to a LUCIP currently under development, as well as a LUCAP and LTM Plan to be developed for Site 57.

4.4.5 Groundwater Alternative 5 – Extraction and Treatment

Under Alternative 5, a groundwater extraction system would be installed to contain and remove the contaminants in the groundwater. Contaminated groundwater from within the TCE plume and the area of contamination near well S57MW022 would be pumped to an air stripper for removal of VOCs. The treated groundwater would be discharged to Mattawoman Creek.

Monitoring would include periodic sampling and analysis of groundwater. Sampling and analysis of the air stripper influent and effluent would also be conducted. The objectives of the monitoring would be to determine the effectiveness of the extraction and treatment systems and to determine whether contaminants are migrating off site at unacceptable levels.

Groundwater use restrictions would be implemented to ensure that contaminated groundwater is not used as a source of drinking water until the COC concentrations attain PRGs. The groundwater use restrictions would consist of maintaining records of the groundwater contamination in the Base Master Plan and designating the area as a restricted-use area. The area would be given a designation in the Base Master Plan that would prohibit groundwater use or unauthorized activities that could damage the groundwater extraction system and piping. The information in the Base Master Plan would ensure that the Navy would be able to take adequate measures to minimize adverse human health effects at the time of any future land development.

At least every 5 years, a site review would be conducted to evaluate the analytical results from monitoring samples, evaluate the site status (i.e., the site's use at that time and plans for future use), review environmental laws and regulations in effect at the time of the review, and provide direction for further action, if deemed necessary. Site reviews are required because this alternative would allow contaminants to remain above levels that allow for unlimited use and unrestricted exposure. Site reviews are required because this alternative would allow contaminants to remain above levels that allow for unlimited use and unrestricted exposure. The site would be subjected to a LUCIP currently under development, as well as a LUCAP and LTM Plan to be developed for Site 57.

4.5 SCREENING OF ALTERNATIVES

Alternatives are screened to decrease the number of alternatives that are carried forward for detailed analysis. This step in the FS is conducted, when appropriate, to eliminate alternatives that do not achieve protection of human health and the environment. Alternatives should be eliminated if they are significantly less effective than other more promising alternatives, are not technically or administratively implementable, or have significantly higher costs.

The alternatives developed and described for Site 57 are considered to represent an appropriate range of alternatives. All alternatives are considered effective and implementable. Therefore, all the alternatives developed for Site 57 will be carried forward for detailed analysis.

5.0 DETAILED ANALYSIS OF ALTERNATIVES

5.1 INTRODUCTION

In this section, each remedial alternative developed for Site 57 in Section 4.0 is described and analyzed in detail. The detailed analysis is conducted in accordance with the Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA (EPA, 1988b) and the NCP. The detailed analysis of remedial alternatives provides information for the comparison of alternatives in Section 6.0 and the final selection of a remedial alternative. The following criteria are used for the detailed analysis of each remedial alternative:

Threshold Criteria

- Overall protection of human health and the environment
- Compliance with ARARs and TBCs

Primary Balancing Criteria

- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume through treatment
- Short-term effectiveness
- Implementability
- Cost

Modifying Criteria

- State acceptance
- Community acceptance

The first two criteria are threshold criteria in that each alternative must meet them. The next five criteria are grouped together because they represent the primary criteria upon which the analysis is based. The alternative that best matches the five primary balancing criteria is proposed to EPA, the state, and the community as the preferred remedy. The final two criteria, state and community acceptance, will be evaluated following comments on the FS and the Proposed Plan and will be addressed once a final decision is made and the Record of Decision (ROD) is being prepared. State and community acceptance must be considered during remedy selection. The following is a description of each of the nine evaluation criteria.

Overall Protection of Human Health and the Environment — The primary requirement for CERCLA remedial actions is that they are protective of human health and the environment. A remedy is protective if it adequately eliminates, reduces, or controls all current and potential risks. All pathways of exposure must be considered when evaluating the remedial alternative. If hazardous substances remain without engineering or land use controls after the remedy is implemented, the evaluation must consider unrestricted land use and unlimited exposure for human and environmental receptors. For those sites where hazardous substances remain and unrestricted use and unlimited access are not allowable, engineering controls, land use controls, or some combination of the two must be implemented to control exposure and ensure reliable protection over time. In addition, implementation of a remedy cannot result in unacceptable short-term risks to or cross-medium impacts on human health and the environment.

Compliance with ARARs and TBCs — Compliance with ARARs and TBCs is one of the statutory requirements for remedy selection. Alternatives are developed and refined throughout the FS process to ensure that they will meet all their respective ARARs or that these is a good rationale for waiving an ARAR. Alternatives may be refined to ensure compliance with these requirements.

Long-Term Effectiveness and Permanence — This criterion reflects the CERLCA emphasis on implementing remedies that will ensure protection of human health and the environment in the future, as well as in the near term. In evaluation of alternatives for long-term effectiveness and the degree of permanence they afford, the analysis should focus on the residual risks that will remain at the site after completion of the remedial action. The analysis should include consideration of the following:

- Degree of threat posed by the hazardous substances remaining at the site.
- Adequacy of any controls (e.g., engineering and land use controls) used to manage the hazardous substances remaining at the site.
- Reliability of those controls.
- Potential impacts on human health and the environment should the remedy fail, based on assumptions included in the reasonable maximum exposure scenario.

Reduction of Toxicity, Mobility, or Volume through Treatment — This criterion addresses the statutory preference for remedies that employ treatment as a principle element by ensuring that the relative performance of the various treatment alternatives in reducing toxicity, mobility, or volume will be assessed. Specifically, the analysis should examine the magnitude, significance, and irreversibility of reductions.

Short-Term Effectiveness — This criterion examines the short-term impacts of the alternatives (i.e., impacts of the implementation) on the neighboring community, workers, and surrounding environment. This includes the potential threats to human health and the environment associated with excavation, treatment, and transportation of hazardous substances. The potential cross-medium impacts of the remedy and the time to achieve protection of human health and the environment should also be analyzed.

Implementability — Implementability considerations include the technical and administrative feasibility of the alternative. Implementability also considers the availability of goods and services (e.g., treatment, storage, or disposal capacity) on which the viability of the alternative depends. Implementation considerations often affect the timing of the various remedial alternatives (e.g., limitations on the season in which the remedy can be implemented, the number and complexity of material-handling steps that must be followed, the need to obtain permits for off-site activities, and the need to secure technical services).

Cost — Cost includes all capital costs and O&M costs incurred over the life of the project. The focus of the detailed analysis is on the net present values of these costs. Costs are used to select the least expensive or more cost-effective alternative that will achieve the remedial action objectives. A 30-year maintenance life and a 7 percent annual discount factor are used to calculate the present worth of the capital and O&M costs.

State Acceptance — This criterion, which is an ongoing consideration throughout the remediation process, reflects the statutory requirement to provide substantial and meaningful state involvement.

Community Acceptance — This criterion refers to community comments on the remedial alternatives under consideration. Community is broadly defined to include all interested parties. These comments are taken into account throughout the FS process; however, only preliminary assessment of community acceptance can be conducted during development of the FS. Formal public comment will not be received until after the public comment period for the preferred alternative is held.

5.2 DESCRIPTION AND ANALYSIS OF SOIL ALTERNATIVES

5.2.1 Soil Alternative 1 – No Action

5.2.1.1 Detailed Description

This alternative would be a "walk-away" alternative that is required under CERCLA to establish a basis for comparison with other alternatives. For this alternative, any existing remedial activities, monitoring programs, and land use controls would be discontinued, and the property could be available for release for unrestricted use.

5.2.1.2 Overall Protection of Human Health and the Environment

Alternative 1 would not be protective of human health and the environment. Contaminated soil would pose a potential future threat under the construction worker and residential exposure scenarios. Soil contaminants would continue to migrate to groundwater.

5.2.1.3 Compliance with ARARs and TBCs

Alternative 1 would not comply with ARARs and TBCs, including risk-based concentrations, and MDE clean-up standards.

5.2.1.4 Long-Term Effectiveness and Permanence

The current and future threats to human health and the environment would remain. There would be no long-term management controls; therefore, the adequacy and reliability of controls would not be applicable. There would be no long-term monitoring program to confirm that further contaminant migration from the site to the environment is not occurring.

5.2.1.5 Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative 1 would not include treatment to reduce the toxicity, mobility, or volume of hazardous substances at the site.

5.2.1.6 Short-Term Effectiveness

Alternative 1 would not pose any short-term risks to the local community or on-site workers during implementation because no actions would occur. There would be no environmental risks from implementation.

5.2.1.7 Implementability

There would no remedial actions to implement under Alternative 1.

5.2.1.8 Costs

There would be no costs associated with the no-action alternative.

5.2.1.9 State Acceptance

State acceptance will be addressed following receipt of comments on the FS.

5.2.1.10 Community Acceptance

Community acceptance will be addressed in the ROD following the public comment period on the FS and Proposed Plan.

5.2.2 Soil Alternative 2 – Capping with Land Use Controls

5.2.2.1 Detailed Description

Alternative 2 would consist of the construction of an asphalt and synthetic geomembrane cap over the area where VOCs exceed PRGs based on protection of groundwater and the implementation of land use controls to protect public health. This alternative also includes land use controls. For purposes of this FS, it is assumed that monitoring would be conducted under the selected groundwater alternative. Conceptual design calculations are provided in Appendix H.

Asphalt and Geomembrane Cap

Capping would be a containment action. The purpose of capping is to reduce the rate of surface water infiltration and subsequent contaminant migration to groundwater. An area of approximately 6,500 square feet near Building 292 would be capped (Figure 5-1). A cross-section of the cap is shown on Figure 5-2.

Before cap installation, soil would be excavated to a depth of approximately 2.5 feet to maintain existing grades and to allow for sufficient cover over the geomembrane because vehicles will need to drive over the capped area. Two feet of cover is generally required to protect a geomembrane. The excavated soil would be hauled to a hazardous waste landfill for disposal. The soil is contaminated with a listed hazardous waste (i.e., spent TCE). The average TCE concentration is less than the LDR treatment standard for contaminated soil; therefore, treatment would not be required prior to disposal.

Six inches of select fill would be placed as a sub-base for the geomembrane. The synthetic geomembrane would be installed in the bottom of the excavation and covered with a layer of geotextile. A 9-inch layer of fill would be placed over the geotextile. A 12-inch layer of gravel would be placed as an asphalt sub-base, and a 3-inch layer of asphalt paving would be installed.

Land Use Controls

Land use controls would include land use restrictions to eliminate or reduce exposure pathways and activities that could damage the cap. Land use controls would consist of maintaining records of the soil contamination at Site 57 in the Base Master Plan and designating the site as a restricted-use area. The information in the Base Master Plan would ensure that the Navy would be able to take adequate measures to minimize adverse human health effects or damage to the cap at the time of any future land development or construction activities. Residential development and unauthorized intrusive activities (e.g., excavation) that could damage the cap would not be permitted. EPA and the state would be properly notified of proposed development plans at Site 57 prior to commencement of any construction activities. The site would be subjected to a LUCIP currently under development and a LUCAP and LTM Plan to be developed for Site 57.

Site Review

At least every 5 years, a site review would be conducted to evaluate the site status and determine whether future action is necessary. The site reviews would be required because this alternative would allow contaminants to remain above levels that allow for unlimited use and unrestricted exposure.

5.2.2.2 Overall Protection of Human Health and the Environment

Alternative 2 would be protective of human health and the environment by ensuring that sources of groundwater contamination are covered by an impermeable cap and by controlling future site use with land use restrictions.

5.2.2.3 Compliance with ARARs and TBCs

Soil with contaminant concentrations higher than PRGs based on protection of groundwater would be contained beneath the cap. This alternative would comply with state closure (i.e., capping) and post-closure maintenance and monitoring requirements for solid waste landfills. Off-site transportation and disposal of contaminated soil would comply with RCRA hazardous waste regulations, including LDR treatment standards. There are no location-specific ARARs or TBCs associated with this alternative.

5.2.2.4 Long-Term Effectiveness and Permanence

The source of groundwater contamination would be permanently covered. Although most of the contaminated soil would remain in place, the risks to human health and the environment would be reduced. Land use controls would reduce the potential human health risks and the potential to damage the cap. Capping would effectively reduce the potential for soil contaminants to migrate to groundwater.

The land use controls, LUCIP, and LUCAP, would be protective over the long term. A 5-year periodic review of the site would be conducted as long as contaminants remain above levels that allow for unlimited use and unrestricted exposure. Any private ownership of the land in the future would be controlled under a deed restriction to control land use.

5.2.2.5 Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative 2 would not include treatment to reduce the toxicity, mobility, or volume of the hazardous substances at the site.

5.2.2.6 Short-Term Effectiveness

The remedial activities are not expected to have an adverse effect on the community or the environment. Exposure of workers to the contaminated media during capping would be minimized by the use of appropriate personal protective equipment (PPE) and compliance with a site-specific health and safety plan (HASP) and Occupational Safety and Health Administration (OSHA) regulations.

It is expected that the RAOs and PRGs could be achieved within a construction duration of 3 months.

5.2.2.7 Implementability

Alternative 2 is implementable. Equipment and services necessary to construct the cap are readily available. Land use restrictions can be strictly enforced because the site is located at a military facility. The depth of excavation (less than 1 foot) would not be expected to damage underground utilities in the area.

5.2.2.8 Cost

The estimated costs for Alternative 2 would be as follows:

Capital ($): 492,400
O&M ($/yr): 600
Present worth ($): 526,000

The present-worth cost estimate is based on a 30-year monitoring period. Details of the cost estimates are provided in Appendix I.

5.2.2.9 State Acceptance

State acceptance will be addressed following receipt of comments on the FS.

5.2.2.10 Community Acceptance

Community acceptance will be addressed in the ROD following the public comment period on the FS and Proposed Plan.

5.2.3 Soil Alternative 3 – Excavation and Off-Site Disposal

5.2.3.1 Detailed Description

Alternative 3 would consist of removal and disposal of all soil that contaminated at levels above PRGs for protection of groundwater and protection of human health under industrial and residential exposure scenarios. No monitoring, land use controls, or 5-year site reviews would be required. The site area would be available for unlimited use and unrestricted exposure (with respect to contaminated soil).

Soil near Building 292 that is contaminated with VOCs and arsenic would be excavated and hauled off site for disposal. The soil would be disposed at an off-site permitted hazardous waste landfill. This soil is contaminated with a listed hazardous waste (i.e., spent TCE). Based on the analytical data for the site, however, the average TCE concentration in the soil would be less than the LDR treatment standard for contaminated soil. Therefore, treatment would not be required prior to disposal. The excavation would cover approximately the same area as the cap for Soil Alternative 2 (Figure 5-1). The average depth of contamination is estimated to be approximately 8 feet. It is estimated that approximately 1,925 cubic yards of material would require excavation. There is a storm sewer in this area that may be damaged during excavation. This sewer, and any other underground utilities that may be affected, would be replaced or repaired.

Soil near location S57SB005 that is contaminated with arsenic would also be excavated and hauled off site for disposal. This soil could be disposed at an off-site permitted nonhazardous waste landfill. The arsenic contamination in this area extends to a depth of approximately 6 feet, and the estimated volume is less than 25 cubic yards.

Verification samples would be collected from all excavated areas to ensure that soil with concentrations higher than PRGs were removed. The excavated areas would be backfilled with common fill material and the ground surface would be restored to pre-excavation conditions (e.g., asphalt paving, vegetation).

5.2.3.2 Overall Protection of Human Health and the Environment

Alternative 3 would be protective of human health by removing all contaminated soil. This would reduce the potential for soil contaminants to enter the human exposure pathway through ingestion and dermal contact. This alternative would be protective of the environment by removing contaminated soil that is a source of groundwater contamination.

5.2.3.3 Compliance with ARARs and TBCs

Removal of contaminated soil would comply with the PRGs established for protection of human health and the environment. Off-site transportation and disposal of contaminated soil would comply with RCRA hazardous waste regulations, including LDR treatment standards. There are no location-specific ARARs or TBCs associated with this alternative.

5.2.3.4 Long-Term Effectiveness and Permanence

Contaminated soil would be permanently removed from the site. Land use controls, monitoring, and 5-year site reviews would not be required. The land could be used for any purpose.

5.2.3.5 Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative 3 would not include treatment to reduce the toxicity, mobility, or volume of the hazardous substances at the site.

5.2.3.6 Short-Term Effectiveness

Hauling excavated soil off site would have a short-term impact on the community. Additional traffic would be expected. Although there would be a potential for spills of contaminated soil during transport, all materials would be solids that could easily be cleaned up.

Exposure of workers to contaminated soil during excavation activities would be minimized by the use of appropriate PPE, engineering controls, and compliance with a site-specific HASP and OSHA regulations.

Erosion controls would be provided during excavation to prevent off-site migration of soil contaminants.

It is expected that the RAOs can be achieved within a construction duration of 3 months.

5.2.3.7 Implementability

Alternative 2 would be implementable. Equipment and services for excavation, transportation, and disposal are readily available. The excavation near Building 292 may be deep enough to damage a storm sewer that runs through the area. Repair or replacement of the storm sewer and any other underground utilities that could be damaged by excavation activities would be required.

5.2.3.8 Cost

The estimated costs for Alternative 3 would be as follows:

- Capital ($): 907,000
- O&M ($/yr): 0
- Present worth ($): 907,000

The capital and present-worth costs are the same because there are no annual costs. Details of the cost estimates are provided in Appendix I.

5.2.3.9 State Acceptance

State acceptance will be addressed following receipt of comments on the FS.

5.2.3.10 Community Acceptance

Community acceptance will be addressed in the ROD following the public comment period on the FS and Proposed Plan.

5.3 DESCRIPTION AND ANALYSIS FOR GROUNDWATER ALTERNATIVES

5.3.1 Groundwater Alternative 1 – No Action

5.3.1.1 Detailed Description

This alternative would be a "walk-away" alternative that is required under CERCLA to establish a basis for comparison with other alternatives. For this alternative, any existing remedial activities, monitoring programs, or groundwater use restrictions would be discontinued, and the groundwater could be available for unrestricted use.

5.3.1.2 Overall Protection of Human Health and the Environment

Alternative 1 would not be protective of human health and the environment. Contaminated groundwater could pose a potential future threat under the residential exposure scenario.

5.3.1.3 Compliance with ARARs and TBCs

Alternative 1 would not comply with ARARs and TBCs, including MCLs, risk-based concentrations, and MDE clean-up standards.

5.3.1.4 Long-Term Effectiveness and Permanence

The current and future threats to human health and the environment would remain. There would be no long-term management controls; therefore, the adequacy and reliability of controls would not be applicable. There would be no long-term monitoring program to confirm that contaminant migration from the site is not occurring.

5.3.1.5 Reduction of Toxicity, Mobility, or Volume

Alternative 1 would not include treatment to reduce the toxicity, mobility, or volume of hazardous substances in the groundwater.

5.3.1.6 Short-Term Effectiveness

Alternative 1 would not pose any short-term risks to the local community or on-site workers during implementation because no actions would occur. There would be no environmental risks from implementation.

5.3.1.7 Implementability

There would be no remedial actions to implement under Alternative 1.

5.3.1.8 Costs

There would be no costs associated with the no-action alternative.

5.3.1.9 State Acceptance

State acceptance will be addressed following receipt of comments on the FS.

5.3.1.10 Community Acceptance

Community acceptance will be addressed in the ROD following the public comment period on the FS and Proposed Plan.

5.3.2 Groundwater Alternative 2 – Monitored Natural Attenuation

5.3.2.1 Detailed Description

Under Alternative 2, groundwater contamination would be allowed to naturally attenuate. Monitoring would be performed to ensure the effectiveness of natural attenuation. Groundwater use restrictions would be implemented to ensure that contaminated groundwater is not used as a source of drinking water.

Natural Attenuation

Natural attenuation refers to inherent processes that affect the rate of migration and the concentration of contaminants in groundwater. The most important processes are biodegradation, advection, hydrodynamic dispersion, dilution from recharge, sorption, and volatilization.

Advection and dispersion are the dominant mechanisms responsible for transporting contaminants in groundwater. These processes cause contaminants to spread and mix with uncontaminated groundwater and become diluted with increased travel distance. Dilution from recharge occurs as upgradient groundwater flows into and mixes with contaminated groundwater, causing a reduction in contaminant concentrations. Sorption slows the migration of contaminants relative to the rate of groundwater movement. Volatilization results in the transfer of contaminants to the soil gas in the unsaturated zone above the aquifer. Biodegradation is the only mechanism that can transform some contaminants into innocuous by-products. Biodegradation occurs when indigenous microorganisms reduce the total mass of contamination without the addition of nutrients.

Natural attenuation is effective if the rate of biodegradation, aided by sorption, is rapid enough to prevent significant contamination migration by advection and dispersion. The screening evaluation for monitored natural attenuation (Appendix M.1) concluded that conditions in site groundwater are not favorable to the natural attenuation of chlorinated VOCs. However, the presence of TCE degradation products (i.e., dichloroethenes and vinyl chloride) indicates that some biodegradation is occurring. Additional data would be needed to determine the rate and success of complete degradation to non-toxic end products.

Groundwater Use Restrictions

Groundwater use restrictions would be implemented to eliminate or reduce exposure pathways. Groundwater use restrictions would consist of maintaining records of the groundwater contamination in the Base Master Plan. The information in the Base Master Plan would ensure that the Navy would be able to take adequate measures to minimize adverse human health effects at the time of any future land development. Use of shallow groundwater as a source of drinking water would not be permitted until PRGs are achieved. The site would be subjected to a LUCIP currently under development and a LUCAP to be developed for Site 57.

Monitoring

Monitoring of groundwater would be conducted to evaluate the effectiveness of natural attenuation and to confirm that groundwater contaminant migration is not occurring at unacceptable levels. It is assumed that all 15 existing monitoring wells would be sampled annually and analyzed for TCL VOC, diethyl ether, and natural attenuation parameters (ferrous iron, TOC, alkalinity, nitrate, nitrite, sulfate, sulfide, chloride, carbon dioxide, methane, ethane, and ethene). Based on initial sampling results, the number of analytes or sampling locations could be reduced. A LTM Plan would need to be developed with concurrence from the EPA and state.

Site Review

At least every 5 years, a site review would be conducted to evaluate the analytical results from monitoring samples, evaluate the site status, and determine whether further action is necessary. The site reviews would be required because this alternative would allow contaminants to remain above levels that allow for unlimited use and unrestricted exposure.

5.3.2.2 Overall Protection of Human Health and the Environment

Alternative 2 would be protective of human health by implementing groundwater use restrictions. This would reduce the potential for groundwater contaminants to enter the human exposure pathway through ingestion and dermal contact. Groundwater monitoring would help in confirming the effectiveness of this remedial action, determining whether contaminants are migrating at unacceptable levels, and evaluating whether future action is required.

5.3.2.3 Compliance with ARARs and TBCs

The groundwater contaminant concentrations would exceed chemical-specific ARARs and TBCs until biodegradation, dispersion, dilution, and other natural attenuation factors eventually reduce their concentrations. There are no location- or action-specific ARARs or TBCs associated with this alternative.

5.3.2.4 Long-Term Effectiveness and Permanence

Contaminants would remain in the groundwater. However, groundwater use restrictions would reduce the potential health hazard. Groundwater contaminants could migrate further. However, monitoring would be conducted to determine whether this is occurring at unacceptable levels.

The groundwater use restrictions, LUCIP, and LUCAP would be protective over the long term. A 5-year periodic review of the site would be conducted as long as contaminants remain above levels that allow for unrestricted groundwater use. Any private ownership of the land in the future would need to be controlled under a deed restriction to control groundwater use until PRGs are attained.

5.3.2.5 Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative 2 does not include treatment to reduce the toxicity, mobility, or volume of the hazardous substances in the groundwater.

5.3.2.6 Short-Term Effectiveness

Implementation of the remedial activities would not be expected to have an adverse impact on the community, on-site workers, or the environment.

It is expected that the RAOs could be achieved within 1 month. Groundwater modeling conducted as part of this FS (Appendix M.3) indicated that TCE concentrations would be reduced to attain PRGs in approximately 70 years if the source of contamination is removed.

5.3.2.7 Implementability

Alternative 2 would be implementable. Groundwater use restrictions can be strictly enforced because the site is located at a military facility.

5.3.2.8 Cost

The estimated costs of Alternative 2 are as follows:

- Capital ($): 8,100
- O&M ($/yr): 29,600
- Present worth ($): 397,000

The present-worth cost estimate is based on a 30-year monitoring period. Conceptual design calculations are provided in Appendix H, and details of the cost estimates are provided in Appendix I.

5.3.2.9 State Acceptance

State acceptance will be addressed following receipt of comments on the draft FS.

5.3.2.10 Community Acceptance

Community acceptance will be addressed in the ROD following the public comment period on the FS and Proposed Plan.

5.3.3 Groundwater Alternative 3 – In-Situ Bioremediation

5.3.3.1 Detailed Description

Alternative 3 would consist of treating contaminated groundwater using in-situ bioremediation. Monitoring would be conducted to confirm the effectiveness of the remedy and to ensure that contaminant migration is not occurring at unacceptable levels. Groundwater use restrictions would be implemented until contaminant concentrations attain PRGs. Conceptual design calculations are provided in Appendix H.

In-Situ Bioremediation

For purposes of this FS, it was assumed that HRC (electron donor) would be used to treat the TCE plume, and ORC (electron acceptor) would be used to treat the area near S57MW022 where only cis-1,2-dichloroethene and vinyl chloride were detected. The use of other chemicals may be feasible. The screening evaluation for in-situ biological treatment (Appendix M.3) concluded that conditions in site groundwater may be favorable for treatment of chlorinated VOCs. The presence of TCE degradation products (i.e., dichloroethenes and vinyl chloride) indicates that some biodegradation is occurring. Additional data and treatability studies would be needed to determine the rate and success of complete degradation to non-toxic end products. For purposes of this FS, it was assumed that a single application of chemicals would be needed. However, a subsequent application(s) may be needed if the initial application does not attain PRGs. Treatability studies would help refine this assumption.

HRC is a moderately flowable material that can be injected under pressure into an aquifer using various direct-push technologies. It can maintain dechlorinating conditions in the aquifer for up to a year or more depending on site conditions. HRC can be injected in a grid pattern or as a barrier. A series of barriers can be used for large plumes. These barriers would be installed perpendicular to the groundwater flow direction (e.g., across the valley) at regular intervals throughout the entire length of the plume. HRC would be injected in rows of delivery points to form the each barrier, thereby creating an anaerobic treatment zone oriented to intercept the downgradient migration of contaminants. The spacing between each barrier was based on a 1-year groundwater travel time.

The TCE plume was separated into two areas (Area 1 and Area 2) for conceptual design purposes. The design parameters for each barrier were based on software provided by the HRC vendor. The grid spacing and HRC dose for each barrier are based on the width of the plume, aquifer characteristics (depth to contaminated zone, thickness of contaminated zone, hydraulic conductivity, hydraulic gradient, and seepage velocity), and groundwater chemistry (average concentrations).

Area 1 (source area) begins near Building 292 and extends down the valley to well cluster S57MW009/MW010. The main COCs in this area are cis-1,2-dichloroethene and TCE. This area has higher concentrations, a greater aquifer thickness, and a steeper hydraulic gradient than Area 2. The length of each barrier was estimated to be 160 feet, which is the approximate width of the valley in this area or the area between the valley wall and a structure (e.g., Building 292). HRC barriers would not be installed beneath structures. Each barrier would contain two rows of injection points on 10-foot centers. The spacing between each row would be 5 feet. The total amount of HRC is estimated to be 1,620 pounds for each barrier. Based on the estimated length of the plume and the average seepage velocity, 10 HRC barriers would be installed in Area 1.

Area 2 (mid-plume area) begins near well cluster S57MW009/MW010 and extends down the valley to well cluster S57MW005/MW006. The main COCs in this area are cis-1,2-dichloroethene and TCE. This area has lower concentrations, a smaller aquifer thickness, and a shallower hydraulic gradient than Area 1. The length of each barrier was estimated to be 80 feet, which is the approximate width of the valley in this area or the area between the valley wall and a structure. Each barrier would contain two rows of injection points on 10-foot centers. The spacing between each row would be 5 feet. The total amount of HRC is estimated to be 450 pounds for each barrier. Based on the estimated length of the plume and the average seepage velocity, five HRC barriers would be installed in Area 2.

ORC is a proprietary formulation of intercalated magnesium peroxide that releases oxygen slowly when hydrated. ORC provides the timed release of oxygen to support in-situ aerobic (or oxidative) biodegradation. Grid-based designs are typically recommended for small- to medium-sized contaminant plumes, such as the area of contamination near S57MW022 (Area 3). The design parameters for the grid were based on software provided by the ORC vendor. The grid spacing and ORC dose are based on the width and length of the plume, aquifer characteristics (depth to contaminated zone, thickness of contaminated zone, hydraulic conductivity, hydraulic gradient, and seepage velocity), and groundwater chemistry.

Several assumptions had to be made for Area 3 because there is only one permanent monitoring well in this area. A temporary well (S57TW003) in this area was installed, sampled, and removed in 1999. In addition, the concentrations of cis-1,2-dichloroethene and vinyl chloride are much higher than in Areas 1 and 2, and TCE was not detected. The size of the plume in Area 3 was assumed to be 150 feet by 150 feet; however, the extent of contamination in this area is not well defined. The spacing between injection points would be 10 feet, for a total of 225 injection points. The total amount of ORC is estimated to be 3,600 pounds.

Groundwater Use Restrictions

The groundwater use restrictions, LUCIP, and LUCAP would be the same as for Groundwater Alternative 2, except they would only need to be enforced until treatment attains the PRGs.

Monitoring

Monitoring of groundwater would be conducted to evaluate the effectiveness of the remedy and to confirm that groundwater contamination is not occurring at unacceptable levels. It is assumed that 21 new monitoring wells would be installed upgradient and downgradient of each HRC barrier in Areas 1 and 2 and the ORC grid in Area 3. It is also assumed that all new (21) and existing (15) monitoring wells would be sampled annually and analyzed for TCL VOCs and diethyl ether. Samples from wells in Areas 1 and 2 would also be analyzed for ferrous iron, dissolved iron, dissolved manganese, TOC, alkalinity, nitrate, nitrite, sulfate, sulfide, chloride, carbon dioxide, methane, ethane, and ethene. Samples from wells in Area 3 would also be analyzed for ferrous iron, biochemical oxygen demand (BOD), and chemical oxygen demand (COD). A LTM Plan would need to be developed with concurrence from the EPA and state.

Site Review

If the initial application of HRC and ORC results in attainment of PRGs, 5-year site reviews would not be required. However, if additional applications take longer than 5 years to attain PRGs, such reviews would be required. The site review would be the same as for Groundwater Alternative 2.

5.3.3.2 Overall Protection of Human Health and the Environment

Alternative 3 would be protective of human health and the environment by using in-situ biological treatment to reduce the COC concentrations and by implementing groundwater use restrictions until PRGs are attained. This would reduce the potential for groundwater contaminants to enter the human exposure pathway through ingestion and dermal contact. Groundwater monitoring would help in confirming the effectiveness of this remedial action, determining whether contaminants are migrating at unacceptable levels, and evaluating whether future action is required.

5.3.3.3 Compliance with ARARs and TBCs

This alternative would comply with ARARs and TBCs, including MCLs and MDE clean-up standards for the chlorinated organic COCs. Treatability studies would be needed to determine whether the risk-based PRG for diethyl ether would be attained. However, diethyl ether concentrations only exceeded the PRG in samples collected from wells S57MW008, S57MW011, and S57TW017. This alternative would also comply with action-specific ARARs and TBCs. There are no location-specific ARARs or TBCs associated with this alternative.

5.3.3.4 Long-Term Effectiveness and Permanence

In-situ biological treatment would be expected to be effective over the long term with respect to chlorinated organics. However, treatability studies would be needed to confirm this. Such studies would also be needed to determine the effectiveness of this technology for diethyl ether. The groundwater use restrictions, LUCIP, and LUCAP would be effective in preventing exposure to contaminated groundwater until remedial goals are attained.

5.3.3.5 Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative 3 includes in-situ biological treatment to reduce the toxicity of the hazardous substances in groundwater.

5.3.3.6 Short-Term Effectiveness

Implementation of the remedial activities would not be expected to have an adverse impact on the community, on-site workers, or the environment. There could be short-term impacts to traffic because some of the injection points would need to be located on a parking area or road.

It is expected that this alternative could be implemented within 3 months. Based on a single application of chemical, the estimated time to attain PRGs is 1 year. However, additional applications, if needed, would increase the time to attain PRGs.

5.3.3.7 Implementability

Alternative 3 would be implementable. Equipment and services necessary to inject the HRC and ORC are available. However, care would need to be taken when injecting the HRC and ORC because there are multiple underground utilities in the site area, especially near Building 292. The substantive requirements of an Underground Injection Control (UIC) permit would have to be met for the injection of HRC/ORC.

5.3.3.8 Cost

The estimated costs for Alternative 3 would be as follows:

- Capital ($): 1,229,100
- O&M ($/yr): 50,000
- Present worth ($): 1,320,000

The present-worth cost estimate is based on a 2-year monitoring period and a single application of HRC/ORC. The need for additional applications would increase the cost. Details of the cost estimates are provided in Appendix I.

5.3.3.9 State Acceptance

State acceptance will be addressed following receipt of comments on the FS.

5.3.3.10 Community Acceptance

Community acceptance will be addressed in the ROD following the public comment period on the FS and Proposed Plan.

5.3.4 Groundwater Alternative 4 – Permeable Reactive Barrier

5.3.4.1 Detailed Description

Alternative 4 would treat contaminated groundwater using a PRB and natural attenuation. Monitoring would be conducted to confirm the effectiveness of the remedy and to ensure that contaminant migration is not occurring at unacceptable levels. Groundwater use restrictions would be implemented until contaminant concentrations attain PRGs. Conceptual design calculations are provided in Appendix H.

Permeable Reactive Barrier

The pre-FS investigation assumed that a PRB using iron as the reactive medium would be installed where soil borings S57SB030 through S57SB032 were installed. This area is near the downgradient portion of the TCE plume. For purposes of this FS, it is assumed that the PRB would extend across the valley from location S57SB030 to S57SB032, which is approximately 210 feet (Figure 1-4). This would include a reactive zone gate (70 feet) and a slurry wall funnel on each side of the reactive zone (70 feet each). However, pre-design investigations would need to be conducted to ensure that this location is perpendicular to the groundwater flow direction. The groundwater flow direction in this area (Figure 1-9) is based on a limited number of water-level measurements. Treatability studies could also be conducted to evaluate types of reactive material other than iron.

The depth to the confining unit near the proposed PRB is 15 feet, and the depth to groundwater is approximately 4 feet. Therefore, the height of the PRB would be approximately 11 feet.

The thickness of the reactive zone is based on the groundwater velocity and the required residence time to attain PRGs. The groundwater velocity was estimated based on slug test data from upgradient (well cluster S57MW005/MW006) and downgradient (well S57MW020) of the proposed PRB location. The residence time was estimated using literature-based half-life values for TCE (Batelle, 2000). The half-life values range over an order of magnitude. The actual half-life may vary depending on the iron source and site-specific groundwater chemistry. A treatability study would be required to determine the half-life used for the design. Based on the average groundwater velocity near the PRB location, the average TCE half-life, and various correction factors, the thickness of the reactive zone was estimated to be 3.5 feet. Correction factors are recommended to account for changes in the bulk density of the reactive medium between the laboratory and the field, seasonal variations in groundwater flow, potential loss of reactivity over time, and any other field uncertainties. For purposes of this FS, it is assumed that the reactive medium would need to be replaced after 15 years of operation.

A conceptual plan view and cross-section of the PRB are shown on Figure 5-3.

Natural Attenuation

Groundwater contaminated with cis-1,2-dichoroethene and vinyl chloride near well S57MW022 would be allowed to naturally attenuate. The screening evaluation for monitored natural attenuation (Appendix M.1) indicated that conditions in this area are favorable to the natural attenuation of chlorinated VOCs.

Groundwater Use Restrictions

Groundwater use restrictions, LUCIP, and LUCAP would be the same as described for Groundwater Alternative 2.

Monitoring

The groundwater would be monitored to evaluate the effectiveness of the PRB on the TCE plume and natural attenuation near well S57MW022. Monitoring would also be used to confirm that contaminant migration is not occurring at unacceptable levels. It is assumed that all 15 existing monitoring wells would be sampled annually and analyzed for TCL VOCs and diethyl ether. Based on initial sampling results, the number of analytes or sampling locations could be reduced. A LTM Plan would need to be developed with concurrence from the EPA and state.

Site Reviews

The 5-year reviews would be the same as described for Groundwater Alternative 2.

5.3.4.2 Overall Protection of Human Health and the Environment

Alternative 4 would be protective of human health and the environment by using a PRB to reduce COC concentrations and by implementing groundwater use restrictions until PRGs are attained. This would reduce the potential for groundwater contaminants to enter the human exposure pathway through ingestion and dermal contact. Groundwater monitoring would help in confirming the effectiveness of the remedial action, determining whether contaminants are migrating at unacceptable levels, and evaluating whether future action is required.

5.3.4.3 Compliance with ARARs and TBCs

This alternative would comply with ARARs and TBCs, including MCLs and MDE clean-up standards for the chlorinated organic COCs. Treatability studies would be needed to determine whether the risk-based PRG for diethyl ether would be attained. However, diethyl ether concentrations only exceeded the PRG in samples collected from wells S57MW008, S57MW011, and S57TW017. There are no location-specific ARARs or TBCs associated with this alternative.

5.3.4.4 Long-Term Effectiveness and Permanence

One significant uncertainty with this technology is the longevity of the reactive medium, a term that refers to the time during which the PRB retains the desired reactive and hydraulic performance. Because existing PRBs have been operational for only about 5 years, and because most geochemical assessment tools have been primarily qualitative rather than quantitative or predictive, it is unclear how long a PRB may be expected to retain its performance (Batelle, 2000). The reactive medium may need to be replaced or regenerated in the future.

Contaminants would remain in the groundwater until the entire plume passes through the treatment zone. However, groundwater use restrictions would reduce the potential health hazard. Groundwater contaminants could migrate further. However, monitoring would be conducted to determine whether this is occurring at unacceptable levels.

The groundwater use restrictions, LUCIP, and LUCAP would be protective over the long term. A 5-year periodic review of the site would be conducted as long as contaminants remain above levels that allow for unrestricted groundwater use. Any private ownership of the land in the future would need to be controlled by a deed restriction to control groundwater use until PRGs are attained. The deed restriction would also include the presence of the PRB.

5.3.4.5 Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative 4 uses a PRB to reduce the toxicity of the hazardous substances in groundwater.

5.3.4.6 Short-Term Effectiveness

Implementation of the remedial activities would not be expected to have an adverse impact on the community, on-site workers, or the environment. There could be short-term impacts to traffic because the PRB would be located beneath a road.

It is expected that this alternative could be implemented within 3 months. The time to attain PRGs cannot be estimated at this time without additional studies (treatability testing and additional groundwater modeling).

5.3.4.7 Implementability

Alternative 4 would be implementable. Equipment and services necessary to construct the PRB, including the slurry walls and reactive zone, are available. However, care would need to be taken during installation because an existing sewer and intermittent stream are present in the proposed PRB location. Groundwater use restrictions can be strictly enforced because the site is located at a military facility.

5.3.4.8 Cost

The estimated costs for Alternative 4 would be as follows:

- Capital ($): 668,200
- O&M ($/yr): 20,600
- Present worth ($): 1,046,000

The present-worth cost estimate is based on a 30-year monitoring period and assumes that the reactive medium would be replaced after 15 years. Details of the cost estimates are provided in Appendix I. Key assumptions for the cost estimates are the required thickness of the reactive medium, the dimensions of the reactive area gate and slurry wall funnel, and the longevity of the reactive medium. Treatability testing, additional site characterization in the area of the proposed PRB, and groundwater modeling would be needed to refine the cost estimate prior to installation.

5.3.4.9 State Acceptance

State acceptance will be addressed following receipt of comments on the FS.

5.3.4.10 Community Acceptance

Community acceptance will be addressed in the ROD following the public comment period on the FS and Proposed Plan.

5.3.5 Groundwater Alternative 5 – Extraction and Treatment

5.3.5.1 Detailed Description

Alternative 5 would include extracting groundwater using pumping wells, air stripping to remove COCs, and discharging the treated groundwater to Mattawoman Creek. Monitoring would be conducted to confirm the effectiveness of the remedy and treatment system and to ensure that contaminant migration is not occurring at unacceptable levels. Groundwater use restrictions would be implemented until contaminant concentrations attain PRGs. Conceptual design calculations are provided in Appendix H.

Groundwater Extraction, Treatment, and Discharge

The groundwater extraction system consists of five wells located within the TCE plume and one well located near location S57MW022 that is contaminated with cis-1,2-dichloroethene and vinyl chloride. The individual extraction rates range from 5 to 20 gallons per minute (gpm), with a combined pumping rate of approximately 75 gallons per minute (gpm). The well locations and pumping rates are based on the groundwater modeling presented in Appendix M.2. The wells would extend from the ground surface to approximately 15 to 30 feet bgs, depending on the location. The wells would be screened such that groundwater in the shallow and deep portions of the surficial aquifer would be removed. The combined flows from the extraction wells would be treated using air stripping. The air stripper was designed based on the flow-weighted average concentrations from the extraction wells and assuming that the groundwater would be treated to attain PRGs prior to discharge to Mattawoman Creek. The actual discharge limits may be higher and would need to be determined by MDE. Monthly sampling of the influent and effluent would be conducted to monitor treatment efficiency and ensure that discharge limits are being met. Based on the anticipated influent concentrations and flow rate, treatment of the air emissions from the air stripper would not be required. Groundwater extraction would continue until the PRG for each of the COCs in the groundwater is achieved. The approximate locations of the extraction wells, transfer piping, treatment system, and discharge piping are shown on Figure 5-4.

Groundwater Use Restrictions

The groundwater use restrictions, LUCIP, and LUCAP would be the same as described for Groundwater Alternative 2.

Monitoring

Monitoring of the groundwater would be conducted to evaluate the effectiveness of the groundwater extraction system in reducing COC concentrations. Monitoring would also be used to confirm that contaminant migration is not occurring at unacceptable levels. It is assumed that all 15 existing monitoring wells would be sampled annually and analyzed for TCL VOCs and diethyl ether. Based on initial sampling results, the number of analytes or sampling locations could be reduced. A long-term monitoring plan would need to be developed with concurrence from the EPA and state. It is assumed that the treatment system influent and effluent would be sampled monthly and analyzed for TCL VOCs.

Site Reviews

The 5-year reviews would be the same as described for Groundwater Alternative 2.

5.3.5.2 Overall Protection of Human Health and the Environment

Alternative 5 would protect human health by removing contaminated groundwater. Groundwater use restrictions would be implemented until the PRGs are attained. This would reduce the potential for groundwater contaminants to enter the human exposure pathway through ingestion and dermal contact. Groundwater monitoring would help in confirming the effectiveness of this remedial action, determining whether contaminants are migrating at unacceptable levels, and evaluating whether future action is required.

5.3.5.3 Compliance with ARARs and TBCs

This alternative would comply with ARARs and TBCs, including MCLs, risk-based concentrations, and MDE clean-up standards. The discharge of treated groundwater would comply with state water pollution permit regulations and surface-water-quality standards. The discharge to the atmosphere from the air stripper would comply with state air pollution control regulations. There are no location-specific ARARs or TBCs associated with this alternative.

5.3.5.4 Long-Term Effectiveness and Permanence

Extraction of contaminated groundwater would permanently reduce contaminant concentrations. The groundwater use restrictions, LUCIP, and LUCAP would be effective in preventing exposure to contaminated groundwater until remedial goals are attained. A 5-year periodic review of the site would be conducted as long as contaminants remain above levels that allow for unrestricted groundwater use. Any private ownership of the land in the future would need to be controlled under a deed restriction to control groundwater use until PRGs are attained.

5.3.5.5 Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative 5 uses air stripping to reduce the toxicity of the hazardous substances in the groundwater prior to discharge to Mattawoman Creek.

5.3.5.6 Short-Term Effectiveness

Implementation of the remedial activities would not be expected to have an adverse impact on the community, on-site workers, or the environment.

It is expected that this alternative could be implemented within 5 months. Groundwater modeling conducted as part of this FS (Appendix M.3) indicated that TCE concentrations would be reduced to attain ARARs in approximately 19 years if the source of contamination is removed.

5.3.5.7 Implementability

Alternative 5 would be implementable. Equipment and services necessary to construct the extraction and treatment system are available. However, care would need to be taken during pipe installation because it would cross an existing storm sewer and other underground utilities in the site area. Groundwater use restrictions can be strictly enforced because the site is located at a military facility. The substantive requirements of a VPDES permit would have to be met for discharge of treated groundwater to Mattawoman Creek.

5.3.5.8 Cost

The estimated costs of Alternative 5 are as follows:

- Capital ($): 410,700
- O&M ($/yr): 63,500
- Present worth ($): 1,083,000

The present-worth cost estimate is based on a 19-year operation and monitoring period. Details of the cost estimates are provided in Appendix I.

5.3.5.9 State Acceptance

State acceptance will be addressed following receipt of comments on the FS.

5.3.5.10 Community Acceptance

Community acceptance will be addressed in the ROD following the pubic comment period on the FS and Proposed Plan.

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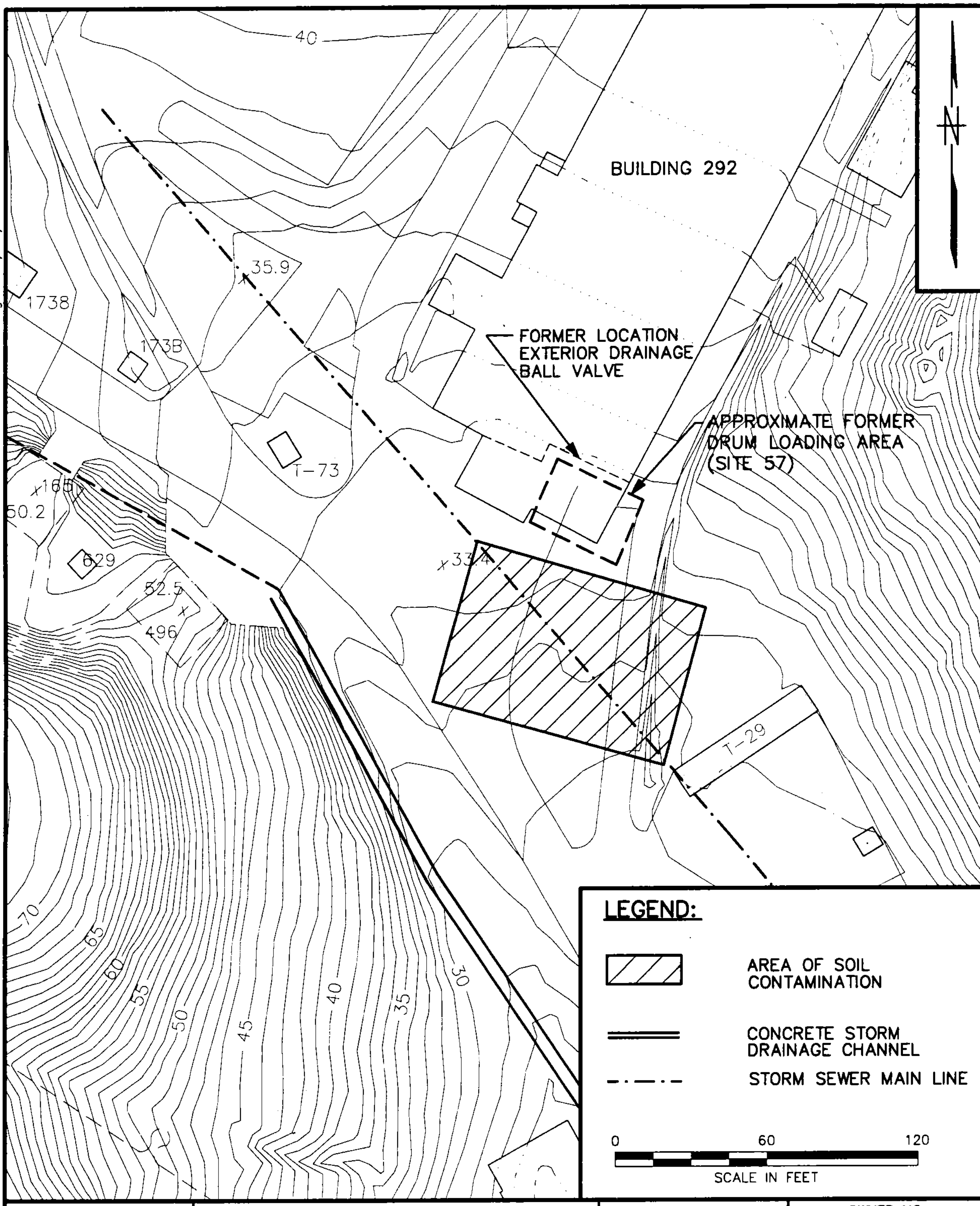

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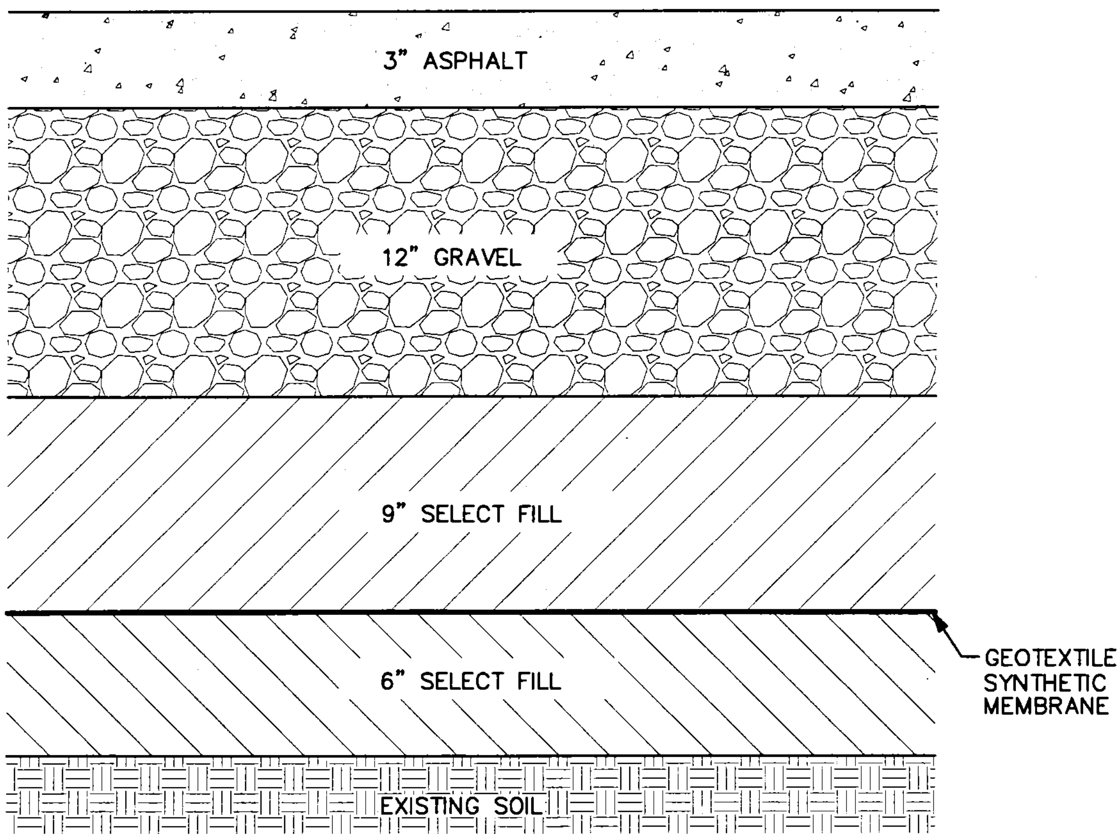
COST/SCHED–AREA			APPROVED BY	DATE
SCALE AS NOTED			DRAWING NO. FIGURE 5–1	REV. 0

FORM CADD NO. SOUTH_AV.DWG – REV 0 – 02/07/97

ACAD: 4020CD01.dwg 05/07/02 HJB PIT



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COST/SCHED-AREA		APPROVED BY	DATE
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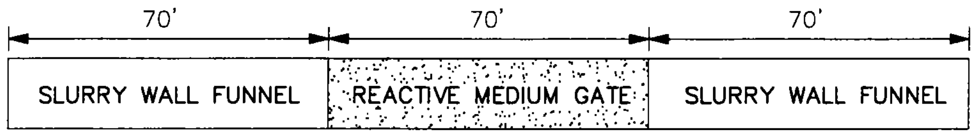
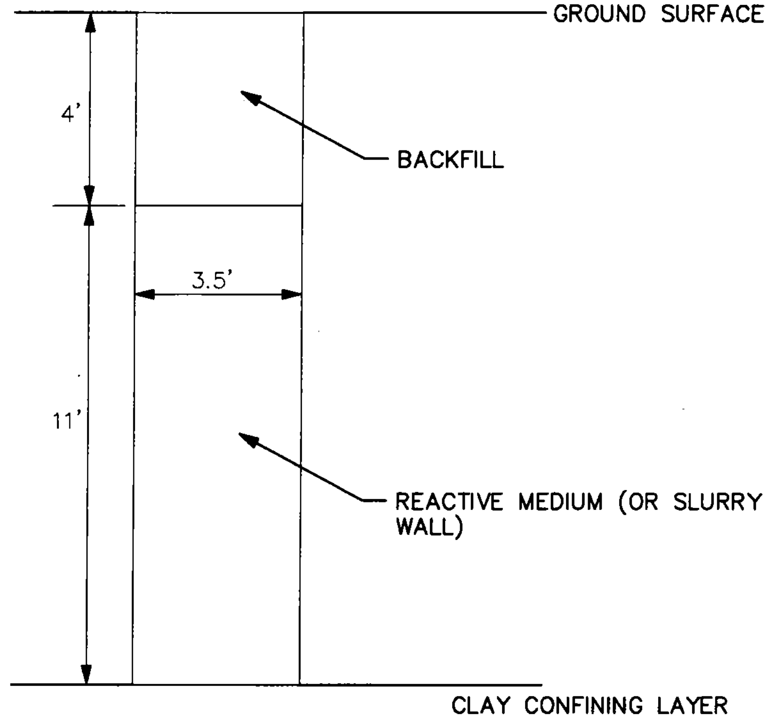
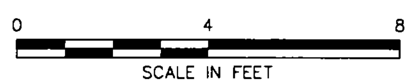
FORM CADD NO. TtNUS_AV.DWG – REV 0 – 1/22/98



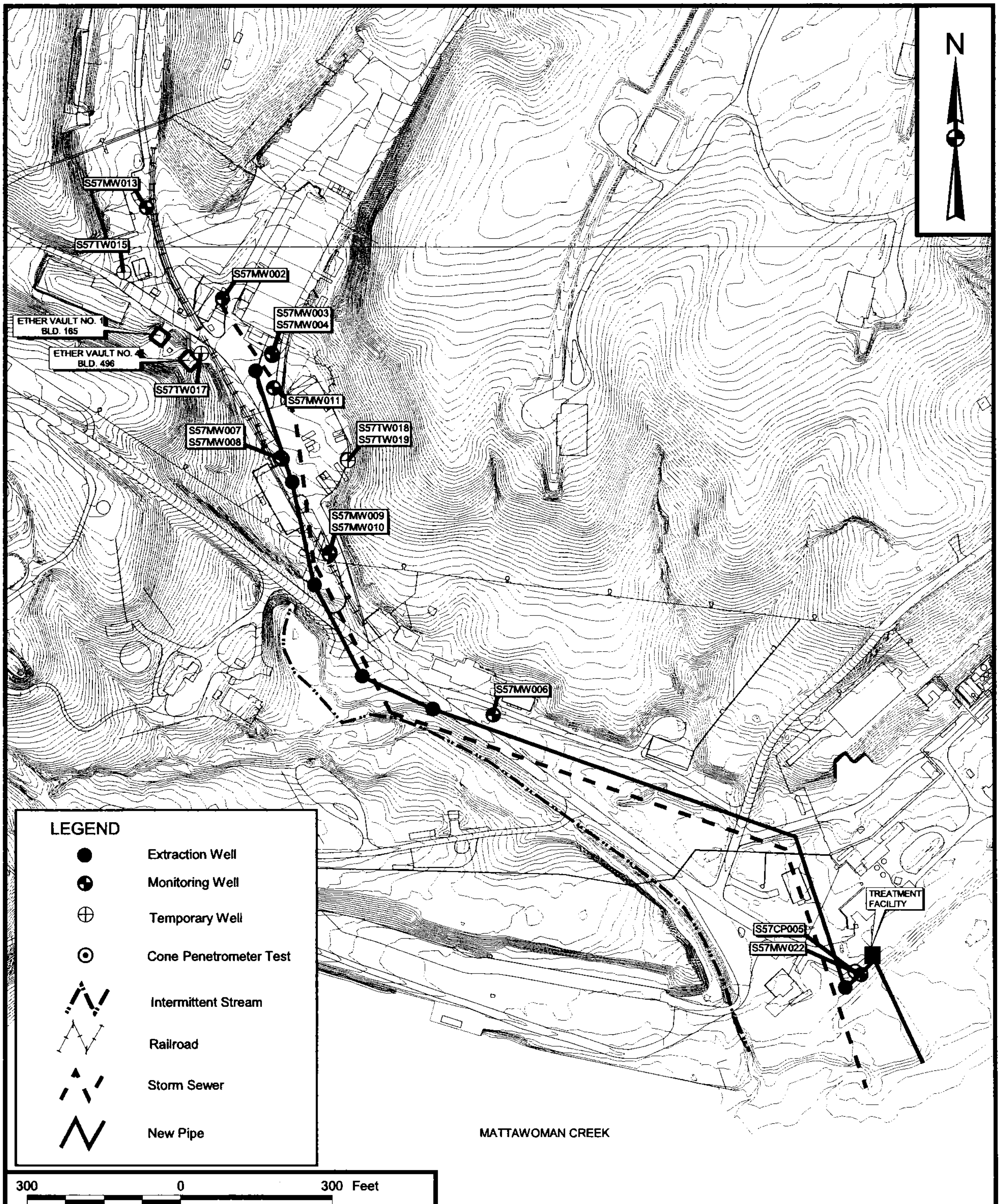
PLAN VIEW
NTS



CROSS SECTION



DRAWN BY HJB DATE 5/6/02	Tetra Tech NUS, Inc.	CONTRACT NO. 4020	OWNER NO. ———
CHECKED BY KCT DATE 5/6/02	GROUNDWATER ALTERNATIVE 4 PERMEABLE REACTIVE BARRIER SITE 57 – FORMER DRUM LOADING AREA IHDIV–NSWC, INDIAN HEAD, MARYLAND	APPROVED BY KCT DATE 5/6/02	
COST/SCHED–AREA		APPROVED BY DATE	
SCALE AS NOTED		DRAWING NO. FIGURE 5–3	REV. 0



DRAWN BY	DATE	Tetra Tech NUS, Inc.	CONTRACT NUMBER	OWNER NO.
K. PEILA	5/13/02		4020	805
CHECKED BY KCT	DATE 5/13/02	GROUNDWATER ALTERNATE 5 - EXTRACTION AND TREATMENT SITE 57 - FORMER DRUM LOADING AREA IHDIV - NSWC INDIAN HEAD, MARYLAND	APPROVED BY KCT	DATE 5/13/02
COST/SCHEDULE-AREA			APPROVED BY —	DATE —
SCALE AS NOTED			DRAWING NO. FIGURE 5 - 4	REV 0

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6.0 COMPARATIVE ANALYSIS OF ALTERNATIVES

In this section, the alternatives are evaluated in relation to one another for each of the evaluation criteria. The purpose of the analysis is to identify the relative advantages and disadvantages of each alternative.

6.1 SOIL ALTERNATIVES

Table 6-1 summarizes the comparative analysis of soil alternatives for Site 57.

6.1.1 Overall Protection of Human Health and the Environment

All the soil alternatives, except Alternative 1 (No Action), would provide adequate protection of human health and the environment.

Alternative 2 (Capping) would protect human health using land use controls to restrict future uses of the site. Alternative 3 (Excavation and Off-Site Disposal) would protect human health by removing contaminated soil that exceeds PRGs based on protection of human health under a residential land use scenario.

Alternative 2 would protect the environment by containing contaminated soil beneath a cap. Alternative 3 would protect the environment be removing contaminated soil that exceeds PRGs based on protection of groundwater.

6.1.2 Compliance with ARARs and TBCs

Alternative 1 would not comply with ARARs and TBCs, including risk-based concentrations and MDE clean-up standards.

Alternative 2 would comply with state closure (i.e., capping) and post-closure maintenance and monitoring requirements for solid waste landfills. Off-site transportation and disposal of contaminated soil would comply with RCRA hazardous waste regulations, including LDR treatment standards. Soil with contaminant concentrations higher than PRGs based on protection of groundwater would be contained beneath the cap.

Removal of contaminated soil under Alternative 3 would comply with the PRGs established for protection of human health and the environment. The PRGs consider risk-based concentrations and MDE clean-up standards. Off-site transportation and disposal of contaminated soil would comply with RCRA hazardous waste regulations, including LDR treatment standards.

6.1.3 Long-Term Effectiveness and Permanence

Alternative 3 would be the most protective over the long term because all contaminated soil would be removed from the site.

Alternative 2 would be less effective over the long term because contaminated soil would remain on site and the land use controls, LUCIP, and LUCAP would be needed to restrict land use. However, the long-term effectiveness of this alternative would be monitored in accordance with a LTM Plan, and corrective measures could be taken if necessary. A 5-year period review of the site would be required because contaminants would remain on site above levels that allow for unlimited use and unrestricted exposure. Any private ownership of the land in the future would need to be controlled under a deed restriction.

Alternative 1 would not be effective in the long term.

6.2.4 Reduction of Toxicity, Mobility, or Volume through Treatment

None of the soil alternatives includes treatment to reduce the toxicity, mobility, or volume of the hazardous substances in soil at the site.

6.2.5 Short-Term Effectiveness

There would be no short-term effectiveness concerns for Alternative 1, because no action would be implemented.

Hauling excavated soil off site under Alternatives 2 and 3 would have a short-term impact on the community. Additional traffic would be expected. Although there would be a potential for spills of contaminated soil during transport, all materials would be solids that could easily be cleaned up. The volume of soil for off-site transport is smaller for Alternative 2. Alternatives 2 and 3 would also cause a short-term disruption of the area immediately south of Building 292.

Exposure of workers to the contaminated soil under Alternatives 2 and 3 would be controlled by the use of appropriate PPE, engineered controls, and compliance with a site-specific HASP and OSHA regulations.

Short-term potential for off-site migration of soil contaminants during construction of Alternatives 2 and 3 would be managed and minimized with proposes erosion and sediment controls.

The RAOs and PRGs could be achieved within construction durations of 3 months for Alternative 2 and 3 months for Alternative 3.

6.2.6 Implementability

All the remedial alternatives are implementable. The depth of excavation (approximately 2.5 feet) under Alternative 2 would not be expected to damage underground utilities in the area. The depth of excavation (approximately 8 feet) under Alternative 3 may be deep enough to damage the storm sewer near Building 292. Repair or replacement of the storm sewer and any other underground utilities that could be damaged by excavation activities would be required.

6.2.7 Cost

The 30-year present-worth costs of the soil alternatives would be as follows:

- Alternative 1: $0
- Alternative 2: $526,000
- Alternative 3: $907,000

6.2.8 State Acceptance

State acceptance will be addressed following receipt of comments on the FS.

6.2.9 Community Acceptance

Community acceptance will be addressed in the ROD following the public comment period on the FS and Proposed Plan.

6.3 GROUNDWATER ALTERNATIVES

Table 6-2 summarizes the comparative analysis of groundwater alternatives for Site 57.

6.3.1 Overall Protection of Human Health and the Environment

All of the groundwater alternatives, except Alternative 1 (No Action) would provide adequate protection of human health and the environment.

Alternative 3 (In-Situ Bioremediation) and Alternative 4 (PRB) protect human health by treating contaminated groundwater in situ. Alternative 5 (Extraction and Treatment) protects human health by removing contaminated groundwater. Groundwater contamination would be allowed to naturally attenuate under Alternative 2. Restrictions on the use of shallow groundwater as a source of drinking water would be imposed for these alternatives until PRGs are attained.

Alternatives 2, 3, 4, and 5 would include groundwater monitoring to ensure protection of the environment.

6.3.2 Compliance with ARARs and TBCs

Alternative 1 would not comply with ARARs and TBCs, including MCLs, risk-based concentrations, and MDE clean-up standards.

Alternatives 2, 3, 4, and 5 would eventually comply with ARARs and TBCs.

6.3.3 Long-Term Effectiveness and Permanence

Because Alternative 2, 3, 4, and 5 involve some form of active or passive groundwater remediation, they are expected to be effective at decreasing groundwater contaminant levels over the long term. Treatability studies would be needed for Alternatives 3 and 4 to confirm the long-term effectiveness with respect to chlorinated organics and to determine the effectiveness for diethyl ether. Monitoring would be needed to confirm the effectiveness of Alternative 2 with respect to chlorinated organics and diethyl ether.

Alternatives 2, 3, 4, and 5 provided continued monitoring in accordance with the LTM Plan and the groundwater use restrictions, LUCIP, and LUCAP that are adequate and reliable controls. Groundwater use restrictions could be removed once the contaminant concentrations have attained PRGs. Any private ownership of the land in the future would need to be controlled under a deed restriction until PRGs have been attained.

A 5-year period review of the site would be conducted for Alternatives 2, 4, and 5 as long as groundwater contaminants remain above levels that allow for unrestricted use. This review would also be required for Alternative 3 if PRGs were not achieved within 5 years.

Alternative 1 would not be effective in the long term.

6.3.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Alternatives 3 and 4 include in-situ biological treatment and a PRB, respectively, to reduce the toxicity of hazardous substances in the groundwater. Alternative 5 includes air stripping to reduce the toxicity of hazardous substances in the groundwater prior to discharge to surface water.

Alternatives 1 and 2 do not include treatment to reduce the toxicity, mobility, or volume of the hazardous substances in groundwater.

6.3.5 Short-Term Effectiveness

No risks to the community, on-site workers, or environment are anticipated for any of the groundwater alternatives. However, activities associated with injection of HRC and ORC, construction of the PRB, and installation of groundwater extraction wells and associated piping under Alternative 3, 4, and 5, respectively, would have short-term impacts on traffic.

Alternative 2 could be implemented within 1 month. The estimated construction duration for Alternatives 3 and 4 is 3 months. The estimated construction duration for Alternative 5 is 5 months. The RAOs would also be achieved within these timeframes.

For Alternative 2, groundwater modeling indicated that TCE concentrations would be reduced to attain PRGs in approximately 70 years. The estimated time to attain PRGs is 1 year for Alternative 3; however, additional application(s) of chemicals, if needed, would increase the time. The time to attain PRGs under Alternative 4 cannot be estimated without additional studies. For Alternative 5, groundwater modeling indicated that TCE concentrations would be reduced to attain PRGs in approximately 19 years. All timeframes assume that the source of groundwater contamination is removed or controlled.

6.3.6 Implementability

All of the remedial alternatives are implementable. Equipment and services needed to implement the alternatives are available. The groundwater use restrictions under Alternatives 2, 3, 4, and 5 can be strictly enforced because the site is located at a military facility.

Care would need to be taken during implementation of Alternatives 3, 4, and 5 because there are underground utilities present, especially near Building 292.

The state would need to develop effluent limits for the discharge of treated groundwater to Mattawoman Creek under Alternative 5.

6.3.7 Cost

The present-worth costs of the groundwater alternatives would be as follows:

- Alternative 1: $0
- Alternative 2: $397,000
- Alternative 3: $1,320,000
- Alternative 4: $1,046,000
- Alternative 5: $1,083,000

6.3.8 State Acceptance

State acceptance will be addressed following receipt of comments on the FS.

6.3.9 Community Acceptance

Community acceptance will be addressed in the ROD following the public comment period on the FS and Proposed Plan.

TABLE 6-1

SUMMARY OF EVALUATION OF SOIL ALTERNATIVES
SITE 57 – FORMER DRUM LOADING AREA
IHDIV-NSWC, INDIAN HEAD, MARYLAND

Evaluation Criteria	Alternative 1 – No Action	Alternative 2 – Capping with Land Use Controls	Alternative 3 – Excavation and Off-Site Disposal
Threshold Criteria			
Overall Protection of Human Health and the Environment	No reduction in potential risks.	Cap and land use controls would reduce risks to human health and the environment.	Removal of all contaminated soil would eliminate risks to human health and the environment.
Compliance with ARARs			
Chemical-specific	Would not comply.	Would comply.	Would comply.
Location-specific	Not applicable.	No ARARs.	No ARARs.
Action-specific	Not applicable.	Can be designed to attain ARARs that apply. Would comply with state landfill closure requirements.	Would comply.
Primary Balancing Criteria			
Long-Term Effectiveness and Permanence	Allows risk to remain uncontrolled.	Cap and land use controls would reduce risks. Monitoring and use restrictions provide adequate and reliable controls.	Removal of all contaminated soil would eliminate risks.
Reduction of Toxicity, Mobility, or Volume through Treatment	No treatment.	No treatment.	No treatment.
Short-Term Effectiveness	No short-term impacts or concerns.	Short-term impacts to community associated with off-site transport of contaminated soil. Exposure of workers to contaminated soil can be adequately controlled. No short-term impacts to environment. Would meet RAOs within 3 months.	Short-term impacts to community associated with off-site transport of contaminated soil. Exposure of workers to contaminated soil can be adequately controlled. No short-term impacts to environment. Would meet RAOs within 3 months.

SUMMARY OF EVALUATION OF SOIL ALTERNATIVES
SITE 57 – FORMER DRUM LOADING AREA
IHDIV-NSWC, INDIAN HEAD, MARYLAND

Evaluation Criteria	Alternative 1 – No Action	Alternative 2 – Capping with Land Use Controls	Alternative 3 – Excavation and Off-Site Disposal
Implementability	Nothing to implement. No monitoring to show effectiveness.	Alternative consists of common remediation practices that are available and implementable.	Alternative consists of common remediation practices that are available and implementable.
Costs			
Capital	$0	$492,400	$907,000
O&M	$0	$600	$0
Present Worth	$0	$526,000	$907,000
Modifying Criteria			
State Acceptance	To be determined.	To be determined.	To be determined.
Community Acceptance	To be determined.	To be determined.	To be determined.

TABLE 6-2

SUMMARY OF EVALUATION OF GROUNDWATER ALTERNATIVES
SITE 57 – FORMER DRUM DISPOSAL AREA
IHDIV-NSWC, INDIAN HEAD, MARYLAND

Evaluation Criteria	Alternative 1 – No Action	Alternative 2 – Monitored Natural Attenuation	Alternative 3 – In Situ Bioremediation
Threshold Criteria			
Overall Protection of Human Health and the Environment	No reduction in potential risks.	Groundwater use restrictions and monitoring would reduce risks to human health and the environment.	Groundwater treatment and groundwater use restrictions would reduce risks to human health and the environment.
Compliance with ARARs			
Chemical-specific	Would not comply.	Would eventually comply.	Would comply.
Location-specific	Not applicable.	No ARARs.	No ARARs.
Action-specific	Not applicable.	Not applicable.	Can be designed to attain ARARs that apply.
Primary Balancing Criteria			
Long-Term Effectiveness and Permanence	Allows uncontrolled risks to remain.	Groundwater use restrictions would reduce risks to human health. Monitoring and use restrictions provide adequate and reliable controls.	Treatment would be expected to be effective over the long term. Treatability studies needed to confirm effectiveness.
Reduction of Toxicity, Mobility, or Volume through Treatment	No treatment.	No treatment.	In situ biological treatment would reduce toxicity of hazardous substances in groundwater.
Short-Term Effectiveness	Not applicable.	No impacts to community, workers, or environment. One month to implement. Approximately 70 years to attain PRGs.	No impacts to community, workers, or environment. Short-term impacts on traffic during HRC and ORC injection. Three months to construct. Approximately 1 year to attain PRGs, unless additional applications needed.

TABLE 6-2

SUMMARY OF EVALUATION OF GROUNDWATER ALTERNATIVES
SITE 57 – FORMER DRUM DISPOSAL AREA
IHDIV-NSWC, INDIAN HEAD, MARYLAND

Evaluation Criteria	Alternative 1 – No Action	Alternative 2 – Monitored Natural Attenuation	Alternative 3 – In Situ Bioremediation
Implementability	Not applicable.	Groundwater use restrictions can be strictly enforced because site is located at a military facility.	Alternative consists of common remediation practices that are readily available and implementable. Care would need to be taken to avoid damage to underground utilities.
Cost			
Capital	$0	$8,100	$1,229,100
O&M	$0	$29,600	$50,000
Present worth	$0	$397,000	$1,320,000
Modifying Criteria			
State Acceptance	To be determined.	To be determined.	To be determined.
Community Acceptance	To be determined.	To be determined.	To be determined.

TABLE 6-2

SUMMARY OF EVALUATION OF GROUNDWATER ALTERNATIVES
SITE 57 – FORMER DRUM DISPOSAL AREA
IHDIV-NSWC, INDIAN HEAD, MARYLAND

Evaluation Criteria	Alternative 4 – Permeable Reactive Barrier	Alternative 5 – Extraction and Treatment
Threshold Criteria		
Overall Protection of Human Health and the Environment	Groundwater treatment, groundwater use restrictions, and monitoring would reduce risks to human health and the environment.	Groundwater extraction and treatment, groundwater use restrictions, and monitoring would reduce risks to human health and the environment.
Compliance with ARARs		
Chemical-specific	Would comply.	Would comply.
Location-specific	No ARARs.	No ARARs.
Action-specific	Can be designed to attain ARARs that apply.	Can be designed to attain ARARs that apply.
Primary Balancing Criteria		
Long-Term Effectiveness and Permanence	Treatment would be expected to be effective over the long term. Treatability studies needed to confirm effectiveness. Monitoring and use restrictions provide adequate and reliable controls.	Extraction and treatment would be effective over the long term. Monitoring and use restrictions provide adequate and reliable controls.
Reduction of Toxicity, Mobility, or Volume through Treatment	Treatment using PRB would reduce toxicity of hazardous substances in groundwater.	Treatment using air stripping would reduce toxicity of hazardous substances prior to discharge to surface water.
Short-Term Effectiveness	No impacts to community, workers, or environment. Short-term impacts to traffic during PRB construction. Three months to construct. Need additional studies to evaluate time to achieve PRGs.	No impacts to community, workers, or environment. Short-term impacts to traffic during installation of wells and piping. Five months to construct. Approximately 19 years to attain PRGs.

TABLE 6-2

SUMMARY OF EVALUATION OF GROUNDWATER ALTERNATIVES
SITE 57 – FORMER DRUM DISPOSAL AREA
IHDIV-NSWC, INDIAN HEAD, MARYLAND

Evaluation Criteria	Alternative 4 – Permeable Reactive Barrier	Alternative 5 – Extraction and Treatment
Implementability	Alternative consists of common remediation practices that are readily available and implementable. Care would need to be taken to avoid damage to underground utilities.	Alternative consists of common remediation practices that are readily available and implementable. Care would need to be taken to avoid damage to underground utilities.
Cost		
Capital	$668,200	$410,700
O&M	$20,600	$63,500
Present worth	$1,046,000	$1,083,000
Modifying Criteria		
State Acceptance	To be determined.	To be determined.
Community Acceptance	To be determined.	To be determined.

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